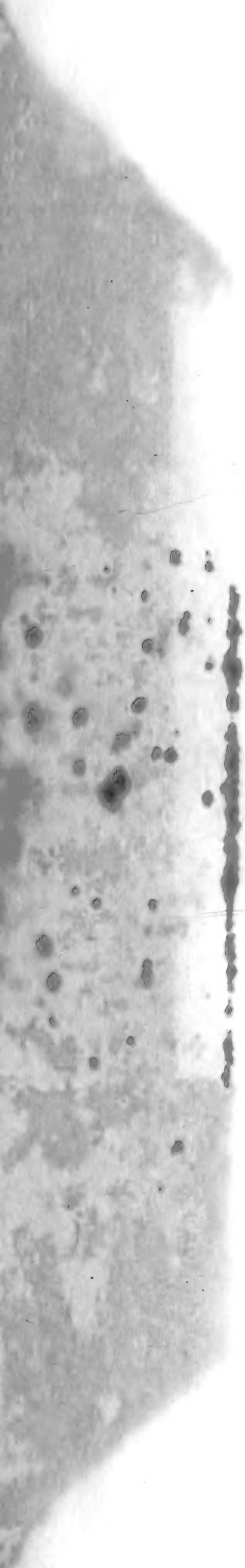


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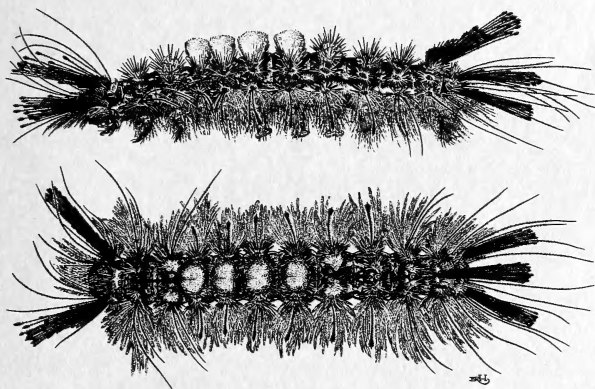
LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



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A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA

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Cover illustration: *Dasychira dorsipennata* larva, dorsal and lateral views. From Fascicle 22.2, "Lymantriidae," by Douglas C. Ferguson, in *Moths of America North of Mexico*. The drawing was done by E. R. Hodges, Scientific Illustrator, Department of Entomology, Smithsonian Institution. (Reproduced by permission of the author.)

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 32

1978

Number 1

Journal of the Lepidopterists' Society
32(1), 1978, 1-2

TYPES OF *PARNASSIUS CLODIUS GALLATINUS* (PAPILIONIDAE)

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ABSTRACT. Types of *Parnassius clodius gallatinus* Stichel, 1907, were discovered in the remnants of the Elrod collection, at the University of Montana, Missoula. Proper labels have been attached to the specimens, and they have been placed in the collection of the American Museum of Natural History.

The description of *Parnassius clodius gallatinus* Stichel was based on a pair illustrated by Elrod (1906). The actual specimens were never seen by Stichel (1907).

While preparing a paper clarifying the nomenclature of *Parnassius clodius* Ménétriés subspecies found in the Rocky Mountains (Ferris, 1976), Cliff Ferris contacted me in an attempt to locate the types of *gallatinus*. A search through the remnants of the Elrod Collection, housed at the University of Montana, Missoula, led to the discovery of the two specimens matching Elrod's 1906 illustrations. They were figured on page 16 of "The Butterflies of Montana."

At the suggestion of Ferris, the two specimens have been placed in the collection of the American Museum of Natural History. The following labels are affixed to the specimen pins:

Holotype Male: A white label partially machine printed in black ink and partially hand lettered in red ink which reads: Gallatin Co. Mont./ Elev. 6800/ Col. E. Koch/ 6-27 1900, and a red label hand lettered in black ink which reads: Holotype ♂/ *Parnassius clodius/ gallatinus* Stichel/ ex. Elrod Coll. Univ./ Mont. S. Kohler 1976.

Allotype Female: A white label partially machine printed in black ink and partially hand lettered in red ink which reads: Gallatin Co. Mont./ Elev. 6800/ Col. Cooley/ 6-27 1900, and a red label hand lettered in

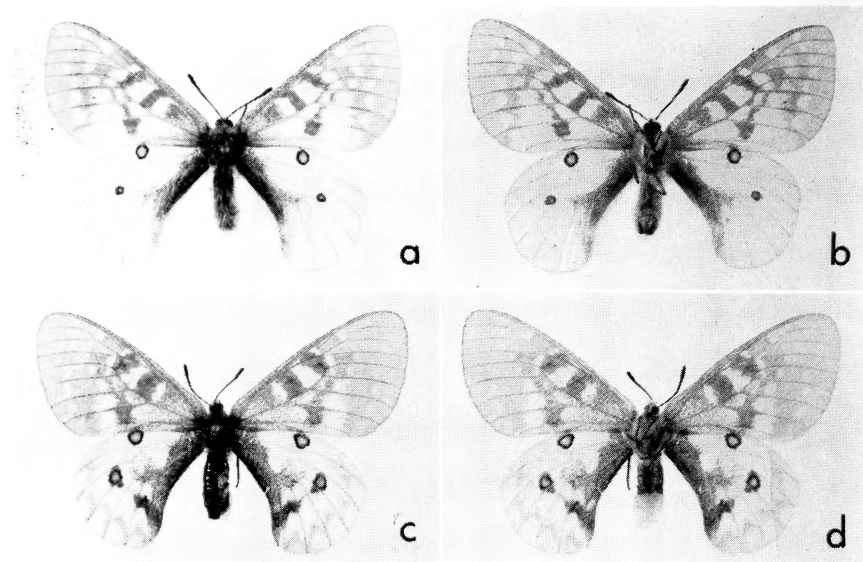


Fig. 1. *Parnassius clodius gallatinus* Stichel: a) holotype male, dorsal; b) same, ventral; c) allotype female, dorsal; d) same, ventral. Photos approximately $\frac{2}{3}$ natural size.

black ink which reads: Allotype ♀ / *Parnassius clodius/ gallatinus* Stichel/ ex. Elrod Coll. Univ./ Mont. S. Kohler 1976.

The specimens are in good condition except for some minor dermestid damage to the abdomen of the female. An additional pair collected by Cooley at the same locality and on the same date was located in the collection of Montana State University, Bozeman, for Ferris by Dr. Norman L. Anderson. These are not designated as paratypes.

Because of the scarcity of copies of Elrod's "The Butterflies of Montana," the type specimens have been illustrated in Figure 1.

ACKNOWLEDGMENTS

I would like to thank Dr. James H. Lowe and the University of Montana for allowing the type specimens to be placed at the American Museum of Natural History, and also Cliff Ferris for comments and assistance.

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- ELROD, M. J. 1906. The butterflies of Montana. Univ. Montana Bull. 10: 1-174.
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SPECIFICITY, GEOGRAPHIC DISTRIBUTIONS, AND
FOODPLANT DIVERSITY IN FOUR *CALLOPHRYS*
(*MITOURA*) (LYCAENIDAE)

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ABSTRACT. The species *C. siva*, *gryneus*, *hesseli*, and *turkingtoni* are examined. Genitalic evidence of their non-conspecificity is provided along with discussion of particular localities of sympatry. Detailed distributional data are illustrated and a documented table of foodplant diversity included. *C. siva* and *gryneus* are oligophagous on numerous species of *Juniperus* (Cupressaceae) which replace each other geographically across the United States. *C. hesseli* is monophagous on *Chamaecyparis thyoides* (Cupressaceae); the foodplant of *turkingtoni* is unknown. Evidence indicates that all local populations are specific to one foodplant species.

Callophrys (*Mitoura*) *nelsoni* (Boisduval), *C. siva* (Edwards), *C. loki* (Skinner), *C. gryneus* (Hübner), and *C. hesseli* (Rawson & Ziegler), aside from taxonomic descriptions, have been subject to several biological and regional studies, but published works (Anderson, 1974; Johnson, 1972; Pease, 1963; Rawson et al., 1951; Remington & Pease, 1955) are very heterogeneous in content and comprehensiveness.

During the last four years I have been compiling data on their distributions and larval foodplants as a base for taxonomic studies of the group. I have also been studying the genitalia of all Nearctic and Neotropical *Callophrys* (*Mitoura*) in detail (Johnson, 1976a). The purpose of this paper is to present detailed distributional data for three of these species (*C. siva*, *C. gryneus*, and *C. hesseli*), demonstrate that *C. siva* and *C. gryneus* are not conspecific, and summarize data on larval foodplants, a number of which are new to the literature. What biogeographical data are known on the newly named *C. turkingtoni* Johnson (Johnson, 1976b) will also be presented. The specificity of *C. siva* and *C. nelsoni* involves several complex problems in the northwestern United States and will be treated in a separate paper (Johnson, 1977).

METHODS AND MATERIALS

Using the collection of the American Museum of Natural History as a basis, additional information on localities and possible local foodplants was gathered by correspondence and recorded county by county. Specimens or photographs were solicited in cases of peripheral or isolated populations, and available published records were included. The research aimed at definitive treatment on the species level only. Genitalic

studies of males and females were performed in areas where *C. siva* and *C. gryneus* were reportedly sympatric. These genitalia were compared with those from many parts of the ranges of *C. siva* and *C. gryneus*, as well as with dissections of other congeners. The number of these specimen dissections included: *C. siva*, 78; *C. gryneus*, 46; *C. hesseli*, 14; *C. turkingtoni*, 1; *C. nelsoni*, 83; *C. rosneri*, 46 (Johnson, 1976a); *C. barryi*, 19 (Johnson, 1976a); *C. byrnei*, 9 (Johnson, 1976a), and *C. loki*, 15.

Geographic ranges were studied to discover areas of insect distribution not coinciding with present published foodplant knowledge, and efforts were then made to make the list for each species complete by identification of exact plants with which the adults were associated by perching behavior (Johnson & Borgo, 1976) or on which oviposition or larvae were observed. Full documentation of each of these methods is given in the foodplant table (Table 1) since a degree of fallibility has been demonstrated in each (Brower, 1958; Downey & Dunn, 1965). An ongoing effort to compile foodplant specimens at one institution was initiated, and plants collected thus far are cited in the table. Since the perching behavior of these insects limits general flight patterns to the vicinity of the foodplant, and since data not only in this study but another (Johnson, in prep.) indicate that *C. siva* and *C. gryneus* are exclusive *Juniperus*-feeders, some useful evidence on larval foodplants in areas where only one juniper species was regionally present could be culled from identification of the plants at the locality indicated on the specimen labels.

The list of plants established as the only *Juniperus* species present in a region (R) or at a locality (L), source of butterfly data (B), source of plant data (P) is:

C. siva: *Juniperus deppeana* Steud., (L) 10 mi. NW Pine Springs, Culberson Co., Texas, (B) R. O. Kendall, (P) Herbarium, University of Texas, Austin; *J. deppeana*, (L) 5 mi. W of McDonald Observatory, Jeff Davis Co., Texas (B) R. O. Kendall, (P) Herbarium, University of Texas, Austin. *Juniperus occidentalis occidentalis* Hook. × *J. osteosperma* Torr. (Little), (R) Washoe Co., Nevada (Reno and vicinity westward), Ormsby and Douglas cos., (B) P. Herlan, (P) Vasek, 1966. *Juniperus monosperma* (Engelm.) Sarg., (L) Sycamore Canyon, NW of Nogales, Santa Cruz Co., Arizona, (B) Share and Clark (American Museum of Natural History (AMNH)), (P) Herbarium, Arizona State University, Tempe. *Juniperus pinchotii* Sudw., (R) Reeves Co., Texas, (B) D. Stallings and M. R. Turner, (P) Adams, 1972, R. P. Adams, pers. comm. *C. gryneus*: *Juniperus virginiana* L., (R) Cass Co., Texas, (B) R. O. Kendall, (P) Adams & Turner, 1970, R. P. Adams, pers. comm. *Juniperus ashei* Buchholz, (R) McLennan Co., Texas, (B) R. O. Kendall, (P) Adams, 1972; Adams & Turner, 1970; R. P. Adams, pers. comm. *Juniperus pinchotii* Sudw., (R) Pecos Co., Texas, (B) R. O. Kendall, (P) Adams, 1972, R. P. Adams, pers. comm. *Juniperus deppeana* Steud., (L) Huejotitlan, Chihuahua, Mexico, (B) AMNH, (P) Little, 1971. *J. deppeana*, (L) Baboquivari Mountains, S of Baboquivari Peak, Pima Co., Arizona, (B) J. D. Gunder (AMNH), (P) Herbarium, Arizona State University, Tempe. *Juniperus virginiana* L. / *J. horizontalis* Moench., (L) Lynxville, along Mississippi River,

TABLE 1. Larval foodplants established by the identification of exact plants.

Foodplant taxa and specimens	Butterfly taxa and specimens
<i>Callophrys (Mitoura) siva</i>	
<i>Juniperus scopulorum</i> Sarg. ¹ Plants, PL: Van Haverbeke, N-2; hybrid index at site— $63 \pm 8\%$ <i>J.</i> <i>scopulorum</i> ; SL: Johnson, 1972. ² Plant specimens, K. Johnson #2 (Smiley Canyon = VanH. N-2; #1 (Chadron), Royal Ontario Museum, Toronto (ROM)). ³	<i>s. siva</i> ; Dawes Co., Nebraska (Smiley Canyon), W of Fort Robinson; Catholic Cemetery, Chadron. ⁴ Butterflies, PC (AC, O, B) ⁵ ; K. Johnson (AMNH). ⁶
<i>Juniperus scopulorum</i> var. <i>columnaris</i> Fasset Plants, PL: Van Haverbeke ND-8, I: T. McCabe, (H) North Dakota State Univ., Fargo; SL: Van Haverbeke, 1968. Plant specimens, Van Haverbeke ND-8, Univ. of Nebraska (UN).	<i>s. siva</i> ; Slope Co., North Dakota (Amidon, along burning coal vein). Butterflies, PC: T. McCabe.
<i>Juniperus scopulorum</i> Sarg. \times <i>J. virginiana</i> L. Plants, PL: Van Haverbeke N-7; hybrid index at site— $48 \pm 6\%$ <i>J.</i> <i>scopulorum</i> ; Range of use of hybrids (Johnson, 1972)— $70 \pm 4\%$ to $36 \pm 4\%$ <i>J. scopulorum</i> . Plant specimens, Van Haverbeke N-7, UN; K. Johnson #3 (Sizer, Keith Co.) ROM.	<i>s. siva</i> ; Garden Co., Nebraska (bluffs above N. Platte River, nr. Lewellen). Butterflies, PC (AC): L. Running, AMNH.
<i>Juniperus virginiana</i> L. Plants, 17 mi S of PL: Van Haverbeke N-4; hybrid index at site— $36 \pm 4\%$ <i>J. scopulorum</i> ; SL: Johnson, 1972. Plant specimens, Van Haverbeke N-4, UN; K. Johnson #4 (locality as above) ROM.	<i>s. siva</i> ; Rock Co., Nebraska (Long Pine Rec. Area). Butterflies, PC (AC, LC, B): K. Johnson, L. Running, AMNH.
Prostrate morph of <i>J. scopulorum</i> Sarg. \times <i>J. virginiana</i> L. \times <i>J. horizontalis</i> Moench.	<i>s. siva</i> ; Saskatchewan, Canada (Val Marie, near Rosefield along Frenchman River).

¹ Taxon of foodplant used (according to nomenclature of USDA (1953) and Little (1971)).² Source of plant data: PL = butterflies were specifically collected at a particular locality studied by Cupressaceae taxonomists; their designation of the site is noted along with the date of their study. "Hybrid index" refers to these studies' calculation of the degree of hybridity in plants at these areas. Plant identifications are noted as "I": I₁, exact substrate plant identified by _____ (H = Herbarium at _____), and location of voucher specimens; I₂, plant identified by data sent to _____ by _____; I₃, foodplant established in original description of butterfly, citation given; I₄, plant identified from specimens sent to _____; I₅, substrate plant established by matching herbarium specimens with butterfly data and establishing that no other species co-occurs, herbarium cited. An "*" following this category ("Plants") means this foodplant usage is well known; SL = other literature which supports this identification.³ The label number and place of deposition of plant specimens collected in this study. An "*" means collection in progress at time of this writing.⁴ Taxon of butterfly concerned (as designated in annotated list), with state and exact locality.⁵ Source of butterfly data: PC = "personally collected by _____." Letters in parentheses following mean: AC, adults commonly observed perching; AI, adults perching but not commonly observed; LC, larvae collected; LO, larvae observed; B, behavior studied in detail; O, oviposition observed.⁶ Location of specimens if not aforementioned person (AMNH = the American Museum of Natural History, New York). M = museum specimens were used as the source of data; ver. means verified by _____, and method. TL = type locality of the insect.

TABLE 1. *Continued*

Foodplant taxa and specimens	Butterfly taxa and specimens
Plants, Schurtz (1971) indicates this area would be included in his tri-parental swarm. Van Haverbeke (pers. comm.) supports this evaluation; I: (H) Univ. Saskatchewan, Regina; I ₁ : D. F. Van Haverbeke (data from R. Hooper, K. Johnson); SL: Little, 1971; Van Haverbeke, 1968; Fassett, 1945. Plant specimens, (H) Univ. Sask. (Sask. Prairie Park); K. Johnson #5* (Hooper) ROM.	Butterflies, PC (AC): R. Hooper (ver. K. Johnson, photo).
<i>Juniperus osteosperma</i> (Torr.) Little Plants, I ₃ : D. F. Van Haverbeke; SL: Emmel & Emmel, 1973; Johnson, 1977; Little, 1971. Plant specimens, K. Johnson #15 (Running, locality as above) AMNH.	s. ssp.; White Pine Co., Nevada (nr. McGill Junction). Butterflies, PC (AC): L. Running, AMNH.
<i>Juniperus californica</i> Carr. Plants +, I ₃ : D. F. Van Haverbeke; SL: Comstock, 1927; Emmel & Emmel, 1973. Plant specimens, K. Johnson #16 (Leone, locality as above) AMNH.	s. <i>juniperaria</i> ; Los Angeles Co., California (Mint Canyon). Butterflies, PC (AC): M. Leone, AMNH.
<i>Juniperus occidentalis occidentalis</i> Hook. Plants, I ₃ : D. F. Van Haverbeke; SL: Johnson, 1977, Little, 1971. Plant specimens, K. Johnson #17 (Buckingham, locality as above).	s. ssp.; Jefferson Co., Oregon (nr. Warm Springs, W on road to Twin Buttes). Butterflies, PC (AC): F. Buckingham, AMNH.
<i>Juniperus occidentalis australis</i> Vasek Plants, I: John H. Lane; SL: Vasek, 1966.	s. ssp.; Tulare Co., California (vic. Kennedy Meadows), San Bernardino Co., California (Big Bear Lake). Butterflies, PC (AC): John H. Lane.
<i>Callophrys</i> (Mitoura) <i>gryneus</i>	
<i>Juniperus virginiana</i> L. Plants, I: K. Johnson; SL: Klots, 1951, Little, 1971. Plant specimens, K. Johnson #21 (locality as above).	<i>g. gryneus</i> ; Ulster Co., New York (West Park, Holy Cross Publications). Butterflies, PC (AI): K. Johnson, AMNH.
<i>Juniperus silicicola</i> (Small) Bailey Plants, I: F. D. Fee, (H) Univ. Florida, Gainesville; I ₁ : (H) Univ. Gainesville; SL: Klots, 1951; Little, 1971. Plant specimens, K. Johnson #10 (St. Augustine locality, Univ. Florida) ROM.	<i>g. sweadneri</i> ; St. Johns Co., Florida (along Ocean Rt. A1A, St. Augustine). Butterflies, PC (AC): F. D. Fee.
<i>Juniperus scopulorum</i> Sarg. × <i>J. virginiana</i> L. Plants, PL: Van Haverbeke M-1; hybrid index near site— $27 \pm 4\%$ <i>J. scopulorum</i> ; Range of use of hybrids (Johnson,	<i>g. gryneus</i> ; Jackson Co., Missouri (general). Butterflies, PC (AC): J. R. Heitzman.

TABLE 1. *Continued*

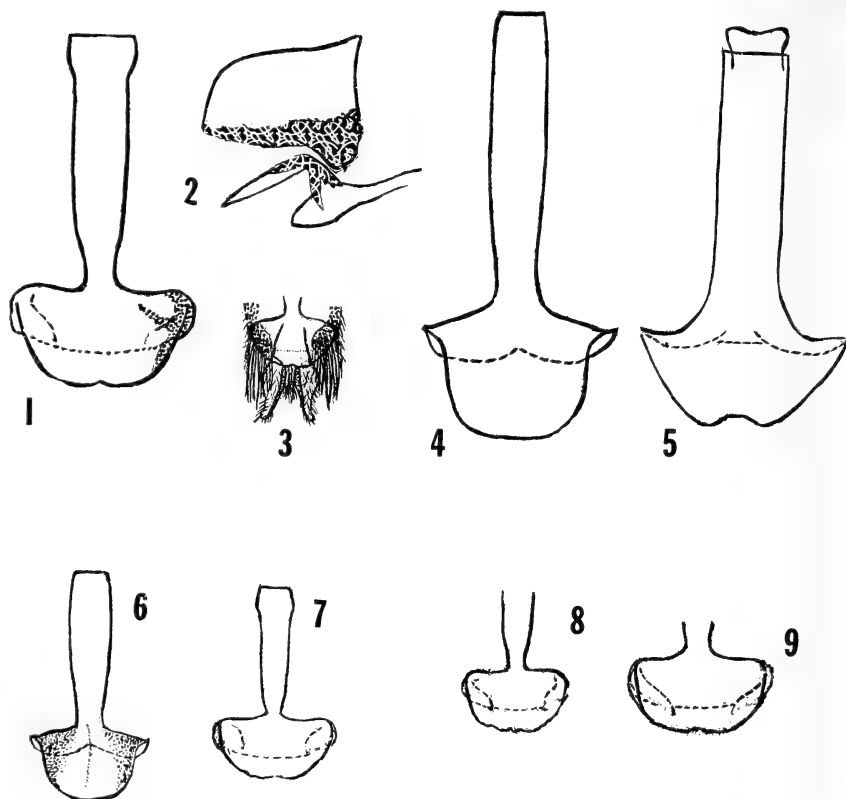
Foodplant taxa and specimens	Butterfly taxa and specimens
1972)—38 ± 4% <i>J. scopulorum</i> to 27 ± 4% <i>J. scopulorum</i> . Plant specimens, K. Johnson #11 (Heitzman, Independence) ROM.	
<i>Juniperus ashei</i> Buchholz Plants, I: J. R. Heitzman; SL: Little, 1971. Plant specimens, K. Johnson #12* (Heitzman, ?) ROM.	<i>g. ssp.</i> ; Barry Co., Missouri (Eagle Rock), also McDonald Co.; Washington and Carroll cos., Arkansas. Butterflies, PC (AC): J. R. Heitzman.
<i>Juniperus pinchotii</i> Sudw. Plants [two examples], I: R. P. Adams (Scott, Roever); SL: Adams, 1972. I: R. O. Kendall; SL: Little, 1971; Adams & Turner, 1970.	<i>g. castalis</i> [two examples]; Armstrong Co., Texas (just below N rim of Palo Duro Canyon, 15–16 mi. S Claude). Butterflies, PC (AC): M. Toliver, H. A. Freeman, J. M. Burns, K. Roever (R. O. Kendall); J. Scott. Bexar Co., Texas (Reo Seco Road, off U.S. Hwy. 281 N of San Antonio). Butterflies, PC (AC, O): R. O. Kendall.
<i>Juniperus virginiana</i> L. × <i>J. horizontalis</i> Moench. Plants, I: (by reason of Schurtz, 1971) D. F. Van Haverbeke; SL: Schurtz, 1971; Little, 1971. Plant specimens, K. Johnson #13 (locality as above).	<i>g. gryneus</i> ; Dane Co., Wisconsin (10 mi. W of Madison). Butterflies, PC (AC): W. Sieker.
<i>Callophrys (Mitoura) hesseli</i>	
<i>Chaemaecyparis thyoides</i> (L.) B.S.P. Plants*, I: S. Hessel, G. W. Rawson, J. B. Ziegler; I ₂ : Rawson et al., 1952; Rawson & Ziegler, 1950 (therein det. by I. M. Johnston, Harvard Univ.).	<i>hesseli</i> ; Ocean Co., New Jersey (Lakehurst, TL). Butterflies, PC (AC, LO, LC): S. Hessel, G. W. Rawson, J. B. Ziegler.

Lacrosse Co., Wisconsin and 5 mi. W of Sauk City, Sauk Co., Wisconsin, (B) F. Arnold and W. E. Sieker, (P) Ross & Duncan, 1949; Schurtz, 1971; D. F. Van Haverbeke, pers. comm. *C. turkingtoni*: *Juniperus flaccida* Schlecht., (R) 10 mi. E of Namiquipa, Chihuahua, Mexico, (B) W. Gertsch and M. Cazier (AMNH), (P) Little, 1971; Herbarium, University of Mexico, Mexico City.

RESULTS

Genitalia of *C. gryneus* and *C. siva*

Genitalia of males and females were studied in three regions where these species were reportedly sympatric (Davis Mountain, Texas; Guadalupe Mountains, New Mexico and Texas; and Baboquivari Mountains, Arizona) and found to be easily separable. However, some traditionally

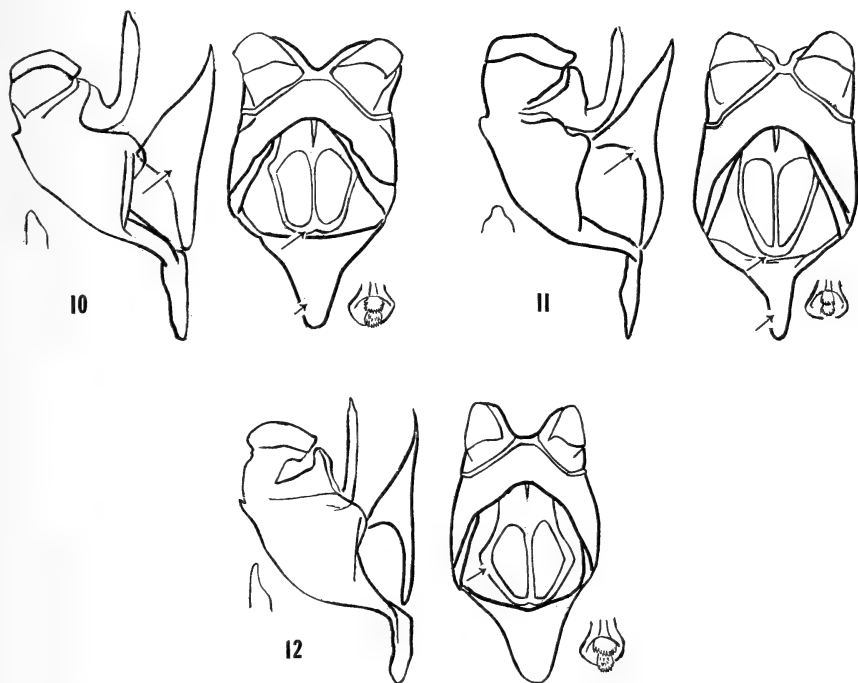


Figs. 1-9. Female genitalia of selected Nearctic *Callophrys* (*Mitoura*) spp. *C. siva siva*: 1, topotypical; 2, heavily sclerotized areas of lamellae and eighth sternite; 3, showing tufts of "hair" allowing diagnosis by naked eye. *C. gryneus*: 4, topotypical. *C. hesseli*: 5, topotypical. Genital plates of sympatric species near Alpine, Texas: 6, *C. gryneus* and 7-9, *C. siva*.

used wing-pattern characters for distinguishing these species (ventral secondaries: post basal spots or pattern of mesial band) were shown to be less reliable (also noted in Johnson, 1976a, 1977). The diagnostic genitalic characters are as follows:

Females (Figs. 1-9). *C. gryneus* (Figs. 4, 6): ductus bursa longer and not "club-ended" as on *siva*; lamellae tapering caudad from antrum, not shouldered as on *siva*, lamellae postvaginalis nearly as long as broad; juncture of lamellae and eighth abdominal sternite not heavily sclerotized or connected.

C. siva (Figs. 1-3, 7-9). Ductus bursa shorter than *gryneus* and "club-ended"; lamellae distinctly shouldered, lamella postvaginalis much broader than long. Juncture of lamellae and eighth abdominal sternite heavily sclerotized, in area between



Figs. 10–12. Male genitalia of selected Nearctic *Callophrys* (*Mitoura*) spp., lateral and posterior views with tip of aedeagus (right) and falces (left): 10, *C. gryneus castalis*, topotypical; 11, *C. siva siva*, topotypical; and 12, *C. hesseli*, topotypical.

1. postvaginalis and 1. antevaginalis forming bulky ridges and convolutions at their juncture, these binding lamellae tightly with eighth abdominal sternite and containing many spines.

[*C. hesseli* (Fig. 5). Easily recognized by unique shape of the lamellae and broad cephalad tapering from the antrum (figured for reference). *C. turkingtoni*: female unknown.]

Males (Figs. 10–12). *C. gryneus* (Fig. 10). Valvae, lateral shape: only barely concave between dorsal and ventral articulation with vinculum; valvae, caudad saccus (dorsal or ventral view): rounded and indented, vaguely shouldered caudad. Saccus: long and broad.

C. siva (Fig. 11). Valvae, lateral shape: deeply concave and rounded between dorsal and ventral articulation with vinculum; valvae, caudad saccus (dorsal and ventral view): parabolic and unindented, no shouldering caudad. Saccus: short and much less broad than *gryneus*.

[*C. hesseli* (Fig. 12). Lateral shape of valvae less broad, quite concave between articulations with vinculum, and much longer caudad; valvae caudad saccus broadly round, indented, and extremely shouldered caudad (figured for reference). *C. turkingtoni* (Johnson, 1976a), easily recognized by extremely long caudad extension of valvae and by heavily sclerotized and spiny area of valvae, caudad saccus.]

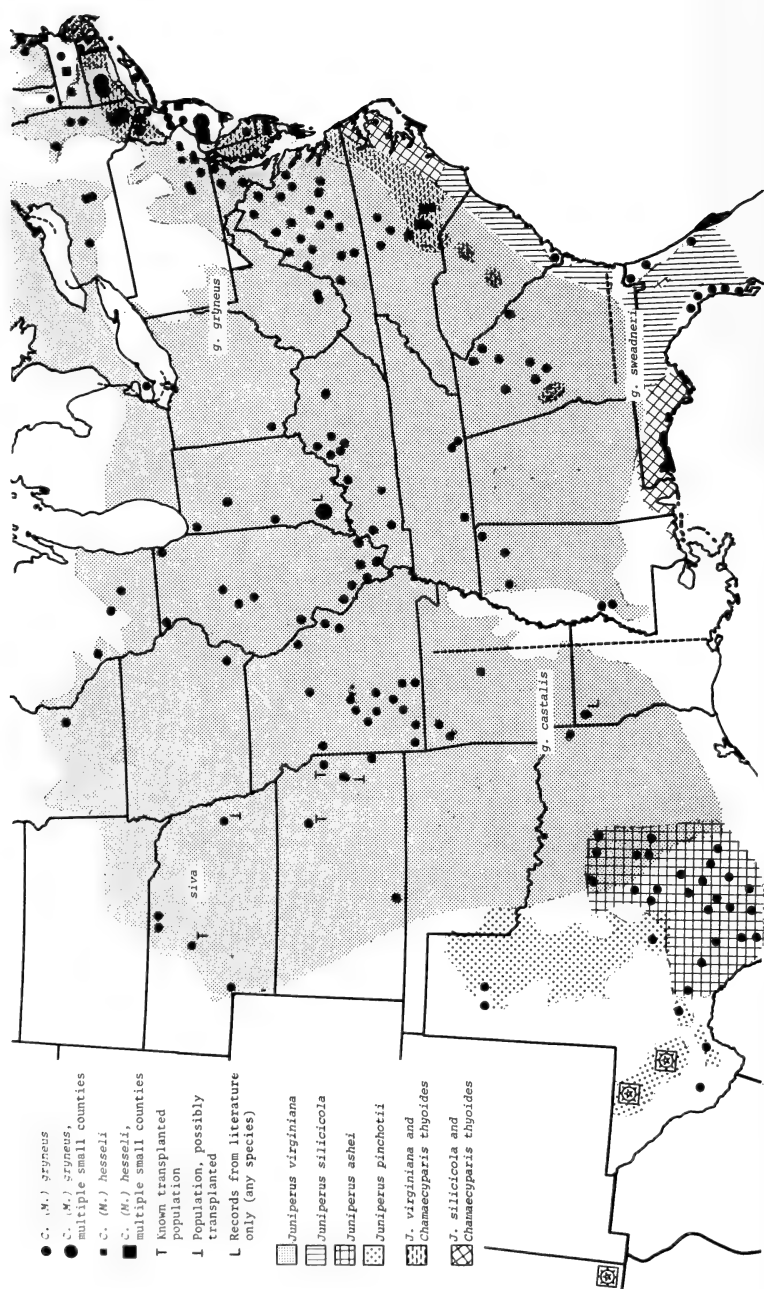


Fig. 13. Nearctic distributions of *Callophrys* (*Mitoura*) *gryneus* and *C. (M.) hessei* and their larval foodplants, *Juniperus* and *Chamaecyparis*. Starred squares indicate sympatric populations of *C. (M.) gryneus* and *C. (M.) siva* diagnosed by genitalic traits. Confusion in current common usage of trinomines only allows for general regional indication as shown by names and broken lines. Plant distributions adapted from Adams & Turner, 1970; Little, 1971; and Adams, 1972.

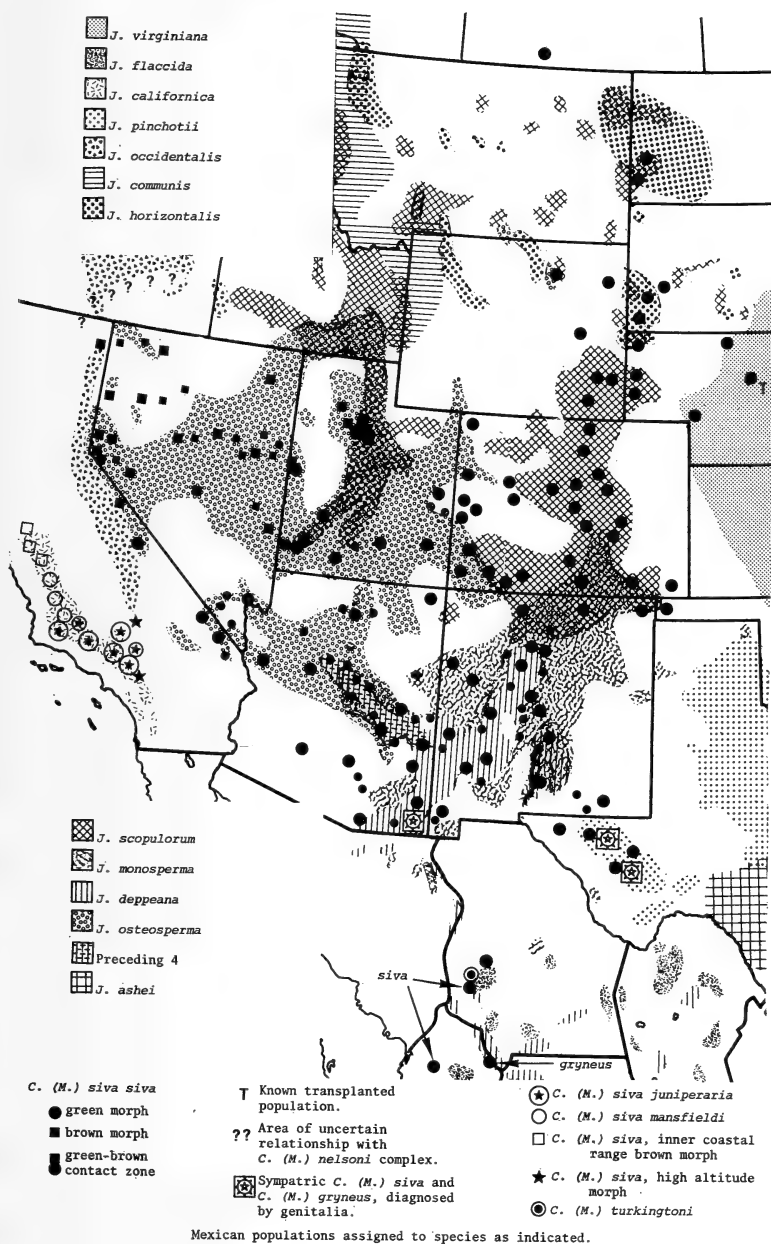


Fig. 14. Nearctic distributions of *Callophrys* (*Mitoura*) *siva* and its larval food-plant *Juniperus* spp., and known range of *C. (M.) turkingtoni*. Plant distributions adapted from Little, 1971. Distribution of *Juniperus horizontalis* shown only as it exceeds *J. scopulorum* northward; hybrid swarms of *Juniperus* spp. illustrated in Fig. 15.

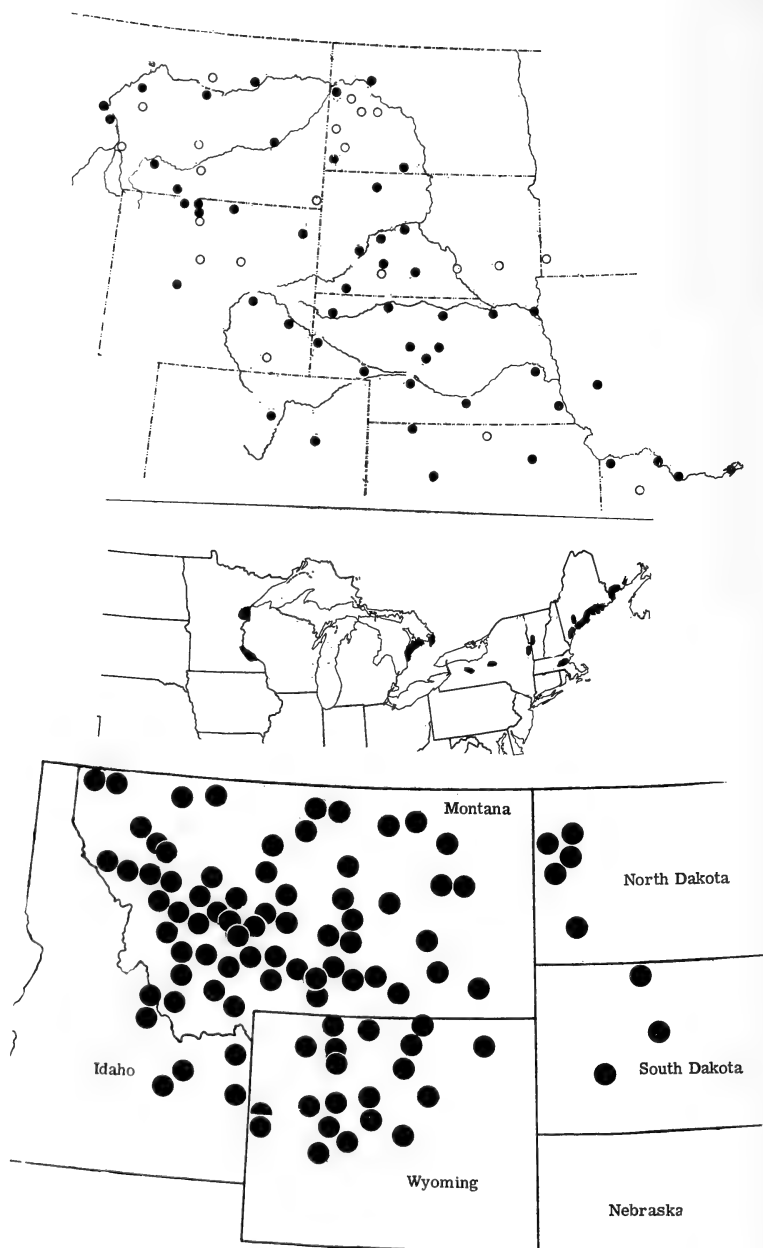


Fig. 15. Bi-parental and tri-parental swarms of divergence in Nearctic *Juniperus*: top, localities indicated by Van Haverbeke (1968) as "hybrid" *J. virginiana* × *J. scopulorum*; center, parental areas of *J. horizontalis* indicating possible centers for

Geographic Distributions and Available Larval Foodplants

Figs. 13 and 14 show the Nearctic distributions of species of *Callophrys* (*Mitoura*) in relation to the ranges of available or established larval foodplants. Fig. 15 shows areas of *Juniperus* ranges that have been botanically demonstrated as "hybrid swarms" (Van Haverbeke, 1968; Schurtz, 1971).

Summary of Data and Current Taxonomic Usages

The following is a review of the current common usage of trinomens in each group with a summary that includes distribution, foodplant(s) as established in this paper, general comments on the phenotype, and notes on the particular significance of each population. Where populations are under study by other lepidopterists, and especially where they are planning to assign new names, I have called these subspecies "ssp." and included the appropriate investigator's name in brackets.

Annotated List

Callophrys (*Mitoura*) *siva*

C. (M.) siva siva. Type locality: Fort Wingate, McKinley Co., New Mexico. Distribution: Workers have named populations distinct from this taxon only on the West Coast, although others are undoubtedly present. Phenotype: There are two general morphs, based on ground color of the ventral secondaries. Great Basin populations (Fig. 14, squares) are brown beneath, whereas others (Fig. 14, plain black circles) are green. Populations of green-browns and mixed greens and browns occur in western Utah (Fig. 14, overlapping square and circles). The brown morph, which Peter Herlan, H. K. Clench, and I have investigated (Johnson, in prep.), is separately treated below. Foodplants: Many western *Juniperus* species (see Table 1) replace each other geographically. "Hybrids" (see Summary and Conclusions) of *J. virginiana* \times *J. scopulorum*, *J. virginiana* \times *J. horizontalis*, and *J. virginiana* \times *J. scopulorum* \times *J. horizontalis* (possibly also *J. occidentalis* \times *J. osteosperma*) occur in western Nevada, adjacent California, and eastern Oregon. All populations of *Callophrys siva* are on erect trees except for one local population (Val Marie, near Rosefield, Saskatchewan, along Frenchman River) on prostrate plants.

C. (M.) siva ssp. [Johnson, in prep.]. The research of Herlan, Clench, and Johnson involves naming this Great Basin population. Distribution: southern Nevada northward to Idaho; brown eastward to Salt Lake City; brown westward to southeast Oregon; broad interface with green morph *C. (M.) siva siva* in western Utah (e.g., Eureka, Dividend, Provo, western Millard Co.). Foodplants: Herlan reported *J. osteosperma*, but probably *J. osteosperma* \times *J. occidentalis* near Reno, Nevada (Vasek, 1966). Apparently not *J. scopulorum* where it is available, al-

←

"hybrid" status with *J. virginiana*; bottom, localities indicated by Schurtz (1970) as "hybrid" *J. virginiana* \times *J. scopulorum* \times *J. horizontalis*.

though Idaho occurrences of *C. (M.) siva* may be lacking due to inadequate sampling.

C. (M.) siva juniperaria (Comstock). Type locality: Los Angeles Co., California. Distribution: western San Bernardino, northern Los Angeles, eastern Kern, and southern and northern Inyo cos.; transition with next subspecies in northern Ventura and northeastern Santa Barbara cos. Foodplant: *Juniperus californica* throughout its range, but in one locality (areas between Phelan and the San Gabriel Mountains, close to the Los Angeles, San Bernardino county lines) it is known to perch also on *J. osteosperma* (J. Lane, pers. comm.).

C. (M.) siva mansfieldi (Tilden). Type locality: Simmler, San Luis Obispo Co., California. Distribution: southern California—western Kern and eastern San Luis Obispo cos. This is somewhat northward of the preceding subspecies. This taxon is ill-defined from that immediately below. Phenotype: deep green morph. Foodplant: *J. californica*.

C. (M.) siva ssp. [Lane, A]. Distribution: north of the preceding entity in the south inner coastal range of California (northern San Luis Obispo, southwestern Fresno, San Benito, eastern Santa Clara, and western Contra Costa cos.). Phenotype: brown morph. Foodplant: *J. californica*.

C. (M.) siva ssp. [Johnson, in prep.]. The identity of reputed *C. (M.) siva* specimens from eastern Oregon and Washington to western Idaho, and their relation to the name *C. (M.) nelsoni*, has been resolved by detailed genitalic studies (Johnson, in prep.). Populations in nearly all of Oregon east of the Cascades to extreme southwest Idaho and extreme southeastern Washington are *C. siva*. Phenotype: burgundy-brown morph. Foodplants: Oregon, Washington—*J. occidentalis*; Idaho—*J. osteosperma*. The taxon in press by Johnson includes only the *J. occidentalis* utilizers; those on *J. osteosperma* represent northward range of another subspecies distributed throughout Nevada and reviewed above.

C. (M.) siva ssp. [Lane, B]. Distribution: High altitudes in the southern Sierra Mountains (e.g., Kennedy Meadows, Tulare Co., California) and San Bernardino Mountains (e.g., Big Bear Lake, San Bernardino Co., California). Phenotype: green morph. Foodplant: *J. occidentalis australis*.

Callophrys (Mitoura) gryneus

C. (M.) gryneus gryneus. Type locality: Rappahanock Co., Virginia. Distribution: eastern and central North America in scattered populations wherever *J. virginiana* occurs. Phenotype: green morph. Foodplants: *J. virginiana*, but not observed feeding on sympatric *J. communis*, prostrate morphs of *J. horizontalis* \times *J. virginiana*, or prostrate morphs of *J. horizontalis* northward; however, apparently utilizes erect morphs of *J. horizontalis* \times *J. virginiana* (see Summary and Conclusions). Particular note: sometimes collected on nectar sources with *C. (M.) hesseli*, but foodplants are segregated by habitat in nature and not interchangeable.

C. (M.) gryneus swadneri (Chermock). Type locality: St. Augustine, St. John's Co., Florida. Distribution: Florida, perhaps southern Georgia, and north along the Atlantic Coast where *J. silicicola* occurs. Phenotype: green morph. Foodplant: *J. silicicola*.

C. (M.) gryneus castalis (Edwards). Type locality: McLennan Co., Texas. Distribution: mainly Texas, but also Chihuahua, Mexico, and areas west of the Mississippi River "gap" in juniper ranges; in addition, used by some workers as a form name within eastern United States populations. Phenotype: green morph. Foodplants: *J. virginiana*, *J. ashei*, and *J. pinchotii*, replacing each other westward. *J. deppeana* and possibly *J. flaccida* in Mexico.

C. (M.) gryneus ssp. [Johnson, in prep.]. Distribution: the Baboquivari Mountains eastward into Cochise Co., Arizona, and possibly southward in disjunct ranges of *J. deppeana*. Phenotype: green morph. Foodplant: *J. deppeana* suspected.

Callophrys (Mitoura) hesseli

C. (M.) hesseli. Distribution: see Fig. 13. Phenotype: green morph. Food-plant: *Chamaecyparis thyoides*.

Callophrys (Mitoura) turkingtoni

C. (M.) turkingtoni, a single specimen known from Namiquipa, Chihuahua, Mexico, in habitat of *J. flaccida*. Phenotype: brown morph.

SUMMARY AND CONCLUSIONS

Interspecific relations. Studies of *C. siva* and *C. gryneus* at several sympatric localities (21 specimens from the Baboquivari Mountains, Pima Co., Arizona; Cochise County (general), Arizona; Guadalupe Mountains, Eddy and Otero cos., New Mexico, Culberson Co., Texas; and Alpine, Brewster Co., Texas) confirmed that they are separable by genitalia of the males and especially the females (Johnson, in prep.). Since town, county, or mountain range is the only data available on some of these specimens, the extent of their microallopatry or microsympatry remains unknown. Biogeographic data suggest that the species may be altitudinally separated at some localities in Texas (*C. siva* on higher altitude *J. deppeana*, *C. gryneus* on lower altitude *J. pinchotii*), but it is likely that interspecific competition occurs at some locations. Sharing of nectar sources may occur, as reported in *C. gryneus* and *C. hesseli* (J. B. Ziegler, pers. comm.). These two species are generally segregated by the habitats of their foodplants. The female genitalia of *C. hesseli* have not been previously figured in the literature and are included in Fig. 5.

Foodplant relations. *C. siva* and *C. gryneus* utilize a broad spectrum of related and equally acceptable *Juniperus* species, which replace or exceed each other in geographic distribution over the Nearctic Realm. There is evidence that every species of *Juniperus* in the Nearctic is utilized, with two exceptions: *J. communis* L. and *J. horizontalis* Moench. Van Haverbeke (1968) and especially Schurtz (1971) have shown that *J. horizontalis* is actually part of a broadly distributed "swarm of divergence" which involves the parental stock to which the names *J. virginiana*, *J. scopulorum*, and *J. horizontalis* have been applied. Van Haverbeke (pers. comm.) prefers Schurtz's interpretation that each of these merits species status but that they are tied by their evolutionary histories, *J. virginiana* being an eastward evolutionary manifestation of *J. scopulorum* and *J. horizontalis* being a northward evolutionary manifestation of this biparental parent stock. Thus, there is little chemical or morphological reason (unless it is the number of needles versus fleshy leaves) that would prevent use of *J. horizontalis* by these *Callophrys (Mitoura)* especially where it is sympatric with utilized *J. virginiana* or *J. scopu-*

lorum. Johnson & Borgo (1976) have shown that the perching behavior of *C. siva* and *C. gryneus* is distinctly patterned and preferenced for heights. They postulate that the nature of this patterned perching behavior selects against prostrate morphs and is at least a partial boundary on their usage as a larval foodplant (Johnson & Borgo, 1977). The importance of the number of needled leaves on both *J. horizontalis* and *J. communis* needs investigation since first instar larvae burrow into these to feed.

Knowledge of the local specificities of the two oligophagous species is quite incomplete, although preliminary evidence from several localities indicates that populations are specific to particular plant species. In Palo Duro Canyon (Randall and Armstrong cos., Texas) *J. scopulorum*, *J. pinchotii*, *J. monosperma*, and hybrids of the latter two occur (Adams, 1972, and pers. comm.). Field data from collectors of *C. gryneus* indicate that *J. pinchotii* is the only foodplant. However, verification is needed by someone who can test this hypothesis directly. Peter Herlan (pers. comm.) reports that the Great Basin brown morph of *C. siva* feeds exclusively on *J. osteosperma*. Perhaps this is true, but Vasek (1966) has suggested that this species introgresses with *J. occidentalis* westward, and the taxonomic relationships of *C. siva* in the northwest basin are now indicated as including two, largely disjunct subspecies, one feeding on *J. occidentalis* in central and eastern Oregon and the other on *J. osteosperma* in Nevada eastward to Utah. In Missouri and Arkansas, *C. gryneus* populations are located on *J. ashei* where it occurs as "islands" within the range of *J. virginiana*. Other *C. gryneus* populations are on *J. virginiana*. This is another location ideal for specificity studies, as are the areas of diversity of juniper species in Arizona and New Mexico. In California, John Lane reports (pers. comm.) *C. siva juniperaria* perching on both *J. osteosperma* and *J. occidentalis* in an area where *J. occidentalis* has been reported as the foodplant. Thus, foodplant relations in *C. siva* and *C. gryneus* mirror situations reported in Burns (1964), Downey (1966), and Downey & Dunn (1965). Local specificities are due to oviposition by the female on the plant species it fed on as a larva. Thus, according to the familiar "Hopkins' Host Principle," specificity is maintained. However, it is obvious that alterations do occur through time and space (as the above authors also indicate), and this is why such species show catholicity when their foodplant usage is viewed as a whole. The mechanism of ovipositional specificity and the nature of chance alterations need further elucidation. Downey & Dunn (1965) suggest that the patterning of Hopkins' Host Principle is not genetic but physiological and undergoes divergence, convergence, and parallelism through

time and space. The present study indicates that similar foodplants available as replacers offer opportunity for divergence, since nearly all barriers posed to these insects by replacer plants have been crossed. Similarly, the remarkable coincidence of distinguishable morphs or subspecies generally within the distribution of one or another foodplant or foodplant relative suggests that foodplant adaptations play an important role in subspeciation. *Callophrys gryneus sweadneri* inhabits the areas of *J. silicicola*, *C. gryneus gryneus* those of *J. virginiana*, and *C. gryneus castalis* those of the transition of the latter plant to the ranges of *J. ashei* and *J. pinchotii*. Relations in the *C. siva* complex, although trinomial knowledge is less complete, are equally distinctive. If one assumes monophagous *C. hesseli* evolved through adaptations of some populations of early *C. gryneus* stock to *Chamaecyparis thyoides*, a similar mechanism is imaginable, especially since *C. thyoides* and *J. virginiana* have undergone a change in their degree of sympatry through time (M. Rosenzweig, pers. comm.) in which populations of *C. thyoides* are now somewhat disjunct, and those of *C. hesseli* apparently extremely so.

Laboratory foodplant experiments with these species have not been extensive, and such data is of limited use in drawing inferences about foodplant utilization or preference in nature (Downey & Dunn, 1965; Downey & Fuller, 1962). However, studies to date indicate that quite divergent Cupressaceae species are at least nutritionally adequate and otherwise edible by some of the *Callophrys* (*Mitoura*) species. There is a need to further clarify the reported acceptance of *J. virginiana* by larvae of *C. hesseli*.

Distributional relations. One comment on the distribution of these insects, with regard to the frequency of transplanted populations is appropriate at this time. Cupressaceae species are widely used both in agricultural and landscape planting, and a number of transplanted *Callophrys* (*Mitoura*) populations have been noted (Figs. 13 & 14). Taxonomists should be especially aware of this when studying the comparative morphology of these butterflies. The occurrence of *C. siva* in planted forest well isolated in central Nebraska, where juniper is raised from Rocky Mountain stock, is an extreme example, as is the occurrence of this insect in a shelter belt along the Missouri River.

ACKNOWLEDGMENTS

Many lepidopterists and botanists contributed data for this study. I owe a special debt to John Lane, Oakley Shields, and Arthur M. Shapiro (Univ. of California, Davis) for discussing *Callophrys* (*Mitoura*) species with me, and to Frederick H. Rindge (American Museum of Natural

History, New York) for providing the facilities of the museum and editing this paper. For general support I am grateful to the staff of the Museum of Natural History, University of Wisconsin, Stevens Point, especially Charles A. Long, Director, and Robert Freckmann, Curator of the Herbarium. Debt is owed John C. Downey (University of Northern Iowa, Cedar Falls) who introduced me to this group and suggested topics for research. The following provided data for which I am very grateful: R. A. Anderson, J. F. Gates Clarke, Ernst J. Dornfield, J. Donald Eff, George Ehle, Scott Ellis, Frank D. Fee, Clifford D. Ferris, Mike Fisher, Richard Funk, Richard Guppy, Lucien Harris, J. Richard Heitzman, Peter Herlan, Sidney Hessel, Ronald Hooper, Roderick R. Irwin, Roy O. Kendall, H. L. King, Alexander B. Klots, Steve Kohler, Henry A. LeBeau, Bryant Mather, James R. Maudsley, Tim McCabe, Lee D. Miller, James Mori, John S. Nordin, Roger Pease, Richard Priestaf, Kilian Roever, Michael Rosenzweig, R. E. Sanford, James Scott, Ernest M. Shull, William Sieker, Michael J. Smith, J. Bolling Sullivan III, Fred Thorne, and J. W. Tilden.

I am indebted to the herbaria at Arizona State University (Tempe); Colorado University (Boulder); University of Florida (Gainesville); University of Mexico (Mexico City); University of Saskatchewan (Regina); and University of Wisconsin (Stevens Point) and especially to Cupressaceae specialists R. P. Adams (Colorado State Univ., Fort Collins) and David F. Van Haverbeke (University of Nebraska, Lincoln) for their comments and aid.

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FOODPLANT, HABITAT, AND RANGE OF *CELASTRINA EBENINA* (LYCAENIDAE)

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ABSTRACT. The larval foodplant of the recently described *Celastrina ebenina* Clench is *Aruncus dioicus* (Walt.) Fernald (Rosaceae), the Goat's-beard. Over 150 adults were raised from eggs and young larvae. The range of the butterfly coincides nicely with that of the plant, from Pennsylvania to North Carolina and Missouri. The habitat for plant and butterfly is moist, rich forest. The closely related *C. pseudargiolus* Boisduval & LeConte is vastly more abundant and ubiquitous than *C. ebenina*, and has a wide variety of larval foodplants. Larvae of *C. ebenina* differ in several respects from those of *C. pseudargiolus*, including color pattern and stellate processes. Also described and discussed are the plant and butterfly associates of *C. ebenina*, flower visitations of the adults, experiments on foodplant specificity, feeding characteristics of the larvae, broods, botany of the foodplant, and geographical distributions, including a number of new locality records. A guide for discovering new colonies of this rare eastern American butterfly is provided.

Except for brief reports (Clench, 1972; Wagner & Showalter, 1976), little has been published on the biology of the poorly known Dusky Blue Butterfly, *Celastrina ebenina* Clench, of the eastern United States. This lycaenid is notable for several reasons. Interpreted for over a century as an aberration or form, it was not recognized as a distinct species until 1972. The colors of the upper surfaces of the males and females are peculiar for being the reverse of the usual situation among plebejine blues in that the males are dull, dark grayish-brown or blackish, while the females are mainly lustrous blue. The insect is regarded as especially rare and local, having been reported previously, usually as just one or a few individuals, from only 12 localities. Knowledge of its foodplant, behavior, habitat, and geographical distribution has been incomplete or lacking.

The present paper records the results of research in 1976. We now understand the ecology of *C. ebenina* far better than we did in the past, and we believe that we have an explanation for the geographical distribution and sporadic occurrence of the species. At the outset of this study, as botanists, we entertained the possibility that the peculiarities of occurrence of *C. ebenina* might be due to specialized larval foodplant preference.

Because of earlier reports of the species there, the area chosen for our field investigations was in the Daniel Boone National Forest, in and

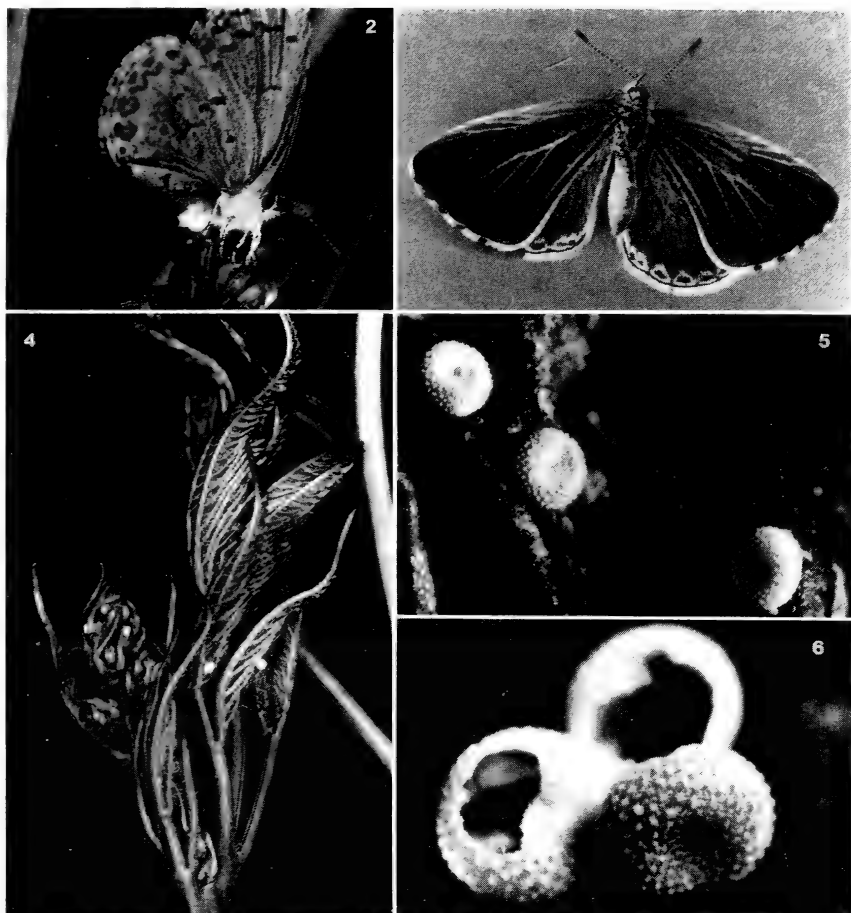
around the Red River Gorge in Powell and Menifee cos., Kentucky, a few miles north of the town of Slade. We found that habitats suitable for *C. ebenina* occur extensively, though sporadically, throughout this area, and in some places the butterfly is common or abundant, though extremely localized, flying with the much more numerous and ubiquitous Common Blue or "Spring Azure," *C. pseudargiolus* Boisduval & LeConte. The topography in the Red River Gorge is made up of steep, abrupt hills and valleys, ranging from 700' altitude in the river and stream beds to over 1300' at the tops of the highest hills. Commanding cliffs of light tan or whitish sandstone crop out at the crests of some of the hills, but in the valleys where *C. ebenina* flies, the most conspicuous rock is a loose, broken, dark-gray shale. The general area is mainly traversed by narrow dirt roads, especially along the larger streams, and there are only occasional two-lane hardtop roads.

Our search for suitable habitats to study was initiated on 17 April 1976. We drove from place to place along the country roads, stopping wherever we encountered roadside puddles or wet streamside flats. In such spots accumulations of butterflies were the rule when it was bright and sunny, especially between the hours of 0900 and 1400. Among the guests at these "puddle parties" we encountered rare males of *C. ebenina*, practically always with at least several and usually many *C. pseudargiolus*, the latter being much more conspicuous in flight. In spite of our success in encountering specimens of *C. ebenina* here and there over an area of perhaps a dozen square miles, at no place were there more than a few individuals. Rare observations of females showed them almost always to be in flight, and following them gave no clue to where their eggs were laid.

Finally, at around 1030 hrs the following day, we came upon an excellent locality—a moist, steep, rocky, north-facing wooded slope, along a narrow dirt road along the Red River. In only 20 min, ca. three dozen *C. ebenina* of both sexes were observed, the females numbering about twice as many as the males. The latter were all more or less worn, dull in appearance, and flying along the edges of the road, occasionally alighting on wet muddy spots (Fig. 1, lower photo). Most of the females, however, were in fresh condition and were flitting around the vegetation on the slopes above and below the road. It was obvious that many of them were engaged in oviposition. They flew rapidly in an "exploratory" pattern, pausing often at a single species of plant, the Goat's-beard, *Aruncus dioicus* (Walt.) Fernald. Occasionally the females landed on the abundant and conspicuous Wild Hydrangea, *Hydrangea arborescens* L., but usually only momentarily.



Fig. 1. *Celastrina chenina* habitat along Red River, Powell Co., Ky. *Upper*: View upstream showing extensive understory growth on forest slope. Butterflies visit *Geranium* flowers here. *Lower*: View downstream showing damp ruts in road where males congregate. (Photo by J. M. Beitel.)



Figs. 2-6. *Celastrina ebenina* adults and eggs: 2, female laying eggs on young *Aruncus* shoots (R. P. Carr); 3, freshly emerged male, showing blue scaling (T. L. Mellichamp); 4, eggs on leaf and inflorescence primordia of *Aruncus* (cf. fig. 14) (T. L. Mellichamp); 5, unhatched eggs; 6, eggs (two of them hatched) showing wall pattern detail (R. P. Carr).

On *Aruncus* the butterflies alighted on very young, unfolding leaflets, and then walked around slowly, laying eggs (Fig. 2). After an individual would fly away, we could easily find the eggs, mainly on the lower blade surfaces, on and between the main veins of the leaflets (Fig. 4). At this time of year the main axis of the plant is still embryonic, and the habit is very different from the mature habit with the inflorescence fully developed (cf. Fig. 13, full-grown plant, and Fig. 14, stage at time of oviposition). When freshly laid, the eggs showed a grayish blue color.

Sometimes several eggs are laid in the same spot, but usually they are laid separately (Figs. 4, 5, & 6). Egg-laying occurred over 1½ hours of observation, and there was no sign of abatement after 1200 hrs when we left the site.

For careful observations, a total of 18 young cuttings like those in Fig. 14 were randomly collected. The two oldest leaves overtop the main shoot at this stage. The main shoot, with its very young leaves and inflorescence primordium, is only about one-fourth the length of the oldest leaf (the large, bipinnate leaf on the right side of the figure) and one-half the length of the next oldest leaf. The softest, most embryonic tissues are those of the primordial main shoot. We found a total of 133 eggs altogether on the collected shoots—35 on the oldest leaves, 26 on the next oldest, and 66 on the young main shoots. Thus, our evidence suggests that the butterflies prefer to lay eggs on the youngest tissues. The number of eggs averaged seven per cutting, but one had 18.

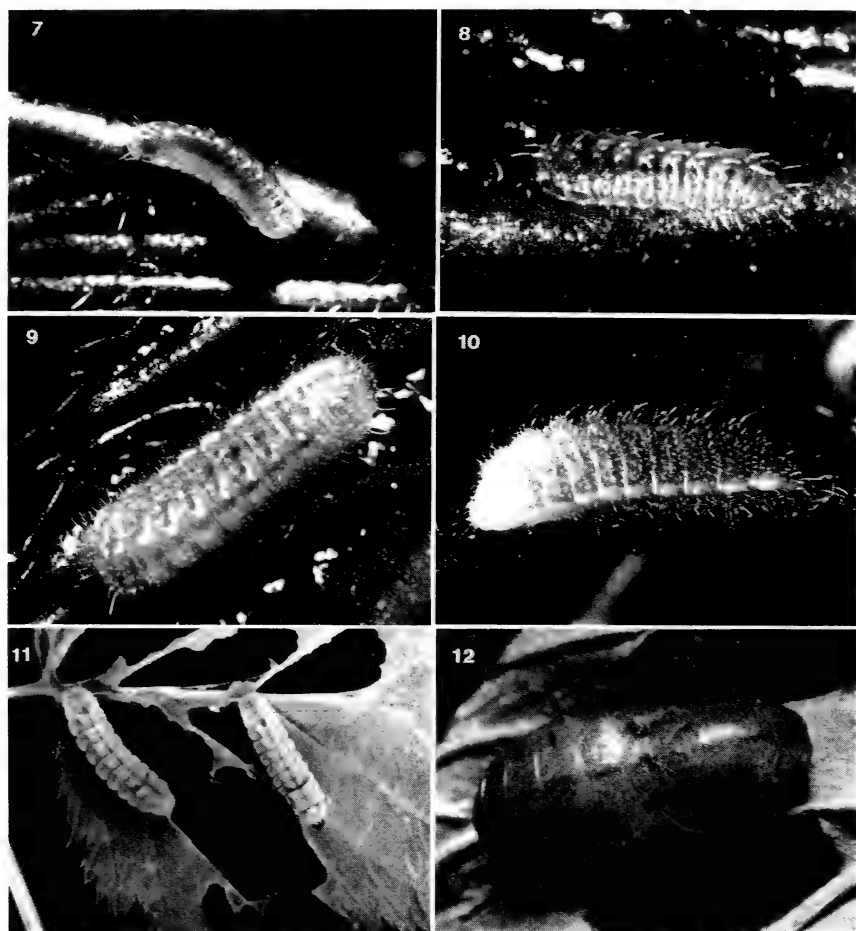
Naturally we wondered whether at least some of the eggs we found did not represent the closely related *C. pseudargiolus*, which flies in large numbers at this locality, a species noted for its polyphagy. Therefore, we decided a couple of weeks later to conduct an experiment designed to help us answer this question, as will be described below.

The plant community on this slope is a rich mixed-mesophytic forest. We recorded a total of 31 trees and shrubs and 56 herbs (including ferns and graminoids) in the area where *C. ebenina* was ovipositing. Most of these plants are typical associates of *Aruncus dioicus*, and some of the more prominent ones will be enumerated later in our discussion of this plant.¹

The best place to find *C. ebenina* adults is in association with other mud-loving butterflies (*C. pseudargiolus*, *Callophrys henrici*, *Erynnis* spp., and *Papilio* spp.) in damp spots along dirt roads and gravelly, sandy, or muddy river flats. Practically all of the "mudding" individuals we observed were males, sometimes as much as a quarter of a mile from the foodplant, although usually much closer. On only two occasions did we find females landing on wet soil. We disturbed one of them several times, but each time it returned.

The only flower which seemed to attract *C. ebenina* at this locality was the Wild Geranium, *Geranium maculatum*. The showy rose-purple flower has a flat five-petalled corolla 3.0–3.5 cm across. Bearded nectaries occur between and at the bases of the petals. The butterflies walk over the top surfaces of the corolla and probe between the petal bases. Later

¹ A complete list of the associated plants at this locality will be sent upon request to readers.

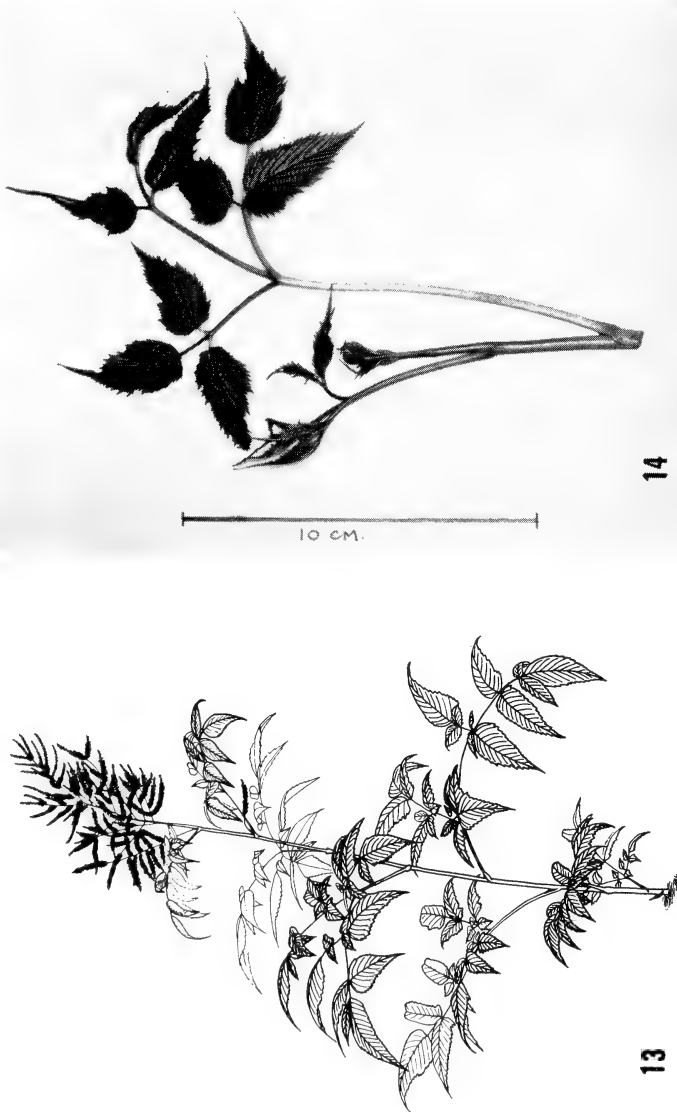


Figs. 7-12. *Celastrina ebenina* immature stages: 7 & 8, instar 1 caterpillars (J. G. Bruce III); 9 & 10, instar 2 caterpillars (J. G. Bruce III); 11, mature caterpillars, showing pale, poorly contrasting pattern and characteristic leaf damage; 12, pupa attached to *Aruncus* leaf (R. P. Carr).

we discovered that the bulk of individuals obtain their nectar from underneath the flower! Both sexes flit from flower to flower, landing on the peduncle or on the underside of the perianth, then walking toward the sepal bases where they insert their proboscises. So positioned on the flowers, the butterflies are invisible from above.²

We recorded all of the species of butterflies we found in association

² Curious to see whether other butterflies behaved in the same manner, we discovered (in Michigan in the middle of May) that *Erynnis juvenalis* displayed the same routine on *Geranium* flowers.



Figs. 13-14. *Celastrina ebenina* foodplant: 13, habit drawing of fully grown *Aruncus dioicus* showing inflorescence (apex) and form of compound leaves in mid-June (Del. J. G. Lacy); 14, young shoot of *Aruncus* at time of oviposition by *C. ebenina* (see text) (T. L. Mellichamp).

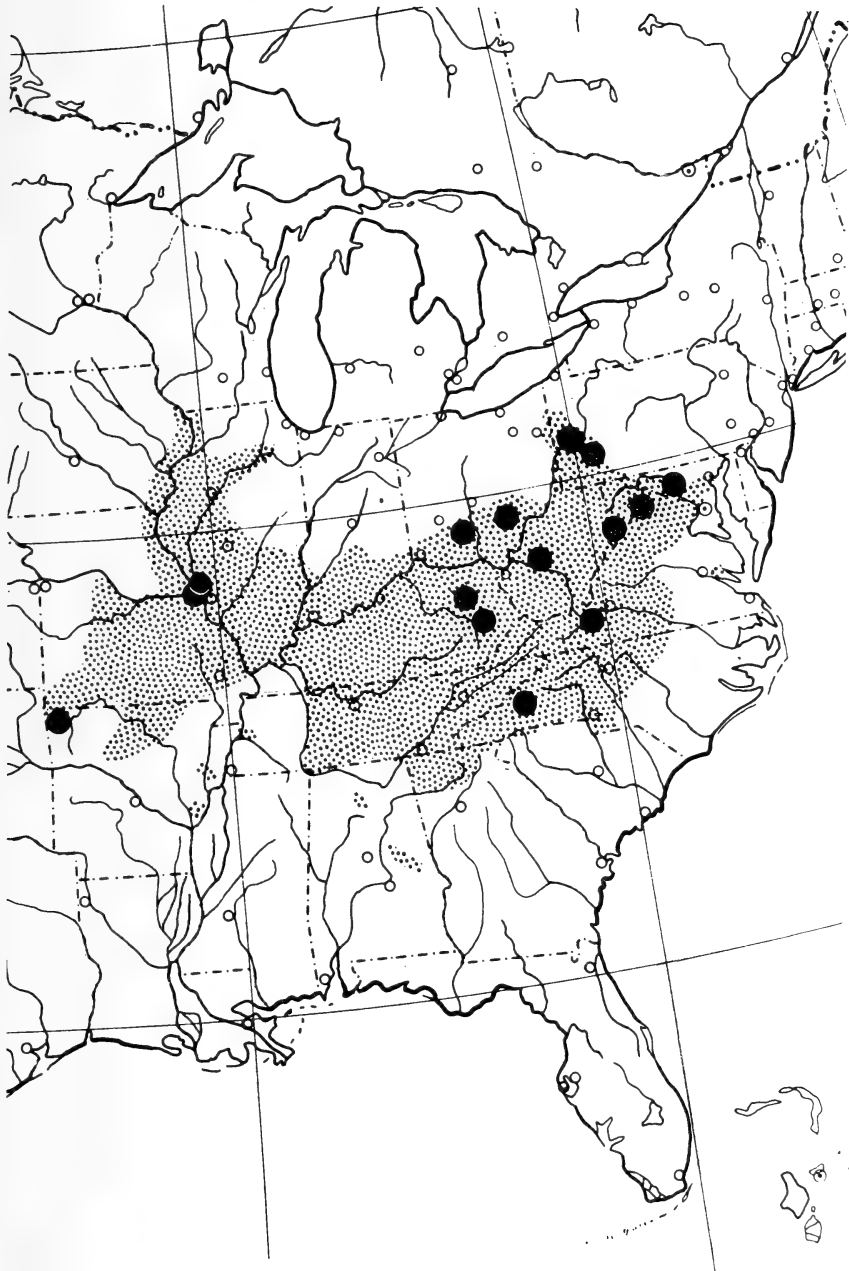


Fig. 15. Geographical distribution of *Aruncus dioicus* (stippling) and documented localities for *Celastrina ebenina* (dots) (T. L. Mellichamp).

with *C. ebenina* on 18 April. The following list is a compilation, since no one locality had all of the species (those marked with an asterisk occurred with *C. ebenina* on wet soil): *Papilio glaucus*,* *P. troilus*,* *Battus philenor*, *Pieris virginiensis*,* *Colias eurytheme*, *C. philodice*, *Polygonia comma*, *P. interrogationis*, *Boloria bellona*, *Phyciodes tharos*,* *Callophrys henrici*,* *Celastrina pseudargiolus*,* *Erynnis brizo*,* *E. juvenalis*,* *Amblyscirtes samoset*, *A. aesculapius*, and *Epargyreus clarus*. On several later visits to the study area by Loran D. Gibson, Amos H. Showalter, and ourselves, the following additional species were observed, most of them, however, well beyond the normal flight period of *C. ebenina*, which ended the first week of May: *Limenitis astyanax*, *Speyeria cybele*, *Asterocampa celtis*, *Euptychia hermes*, *E. cymela*, *Lethe creola*, *L. anthedon*, *Autochton cellus*, *Thorybes pylades*, and *Poanes hobomok*.

Experiment on Foodplant Specificity

The question we addressed ourselves to was whether *C. pseudargiolus* also shared the foodplant of *C. ebenina*. The former is abundant in the Red River Gorge area and is in constant association everywhere with *C. ebenina*. Although we did not observe *C. pseudargiolus* ovipositing upon *Aruncus*, this would not preclude the possibility that it occurs. The number of *Celastrina* eggs we observed was so great that it seemed reasonable to assume, because of their morphological similarity, that perhaps some of them belonged to the abundant species, especially since *C. pseudargiolus* is noted for its varied bill of fare. Literature records show that no less than 10 families of flowering plants contain larval foodplants for this species, and we have discovered early stages of it on such different families as Caprifoliaceae and Cornaceae. It would not have surprised us, therefore, to find *C. pseudargiolus* utilizing *Aruncus*, especially since its larvae have been reported on *Spiraea*, another closely related genus in the same subfamily of Rosaceae.

On 2 May, accordingly, we revisited the Red River Gorge area and collected from seven to nine shoots with attached eggs and minute larvae from each of five colonies of the foodplant, all of them a mile or so separate from one another. These shoots were brought back to The University of Michigan in Ann Arbor, and the eggs and young larvae were raised to adulthood. Extra foodplant shoots were kept in plastic bags and refrigerated to preserve them until they were needed, and additional foodplants were grown for further supplies. The cut bases of the shoots of *Aruncus* bearing eggs and larvae were inserted in jars of water in 1 × 1 × 2 ft glass aquaria covered with a plastic material to keep the

larvae from escaping. Some of the caterpillars drowned when they walked down the main stems into the water, others escaped and were lost, and some died as a result of cannibalism. Nevertheless, a total of 153 butterflies were raised to maturity by the end of the second week in June, 76 males and 77 females. Another eight butterflies came from larvae which escaped from their containers. The first caterpillars pupated on 16 May, 14 days after the field collection, and the first adults to emerge appeared on 23 May. This second brood apparently does not occur in nature (see below).

The results of this experiment were striking. Not only were none of the "checkery" caterpillars of *C. pseudargiolus* noticed among the paler, less contrasty larvae of *C. ebenina* (Figs. 7-9), but not a single one of the adults was *C. pseudargiolus*; all were *C. ebenina*. Furthermore, the 14 additional butterflies from our 18 April eggs were all *C. ebenina*. Also, the four individuals that emerged from dormant chrysalids the following winter were all *C. ebenina*. With *C. pseudargiolus* as abundant as it is in the localities where our collections were made, one would expect at least some evidence of its occurrence on *Aruncus* if it fed on that plant at all.

It is interesting to note that ca. one-third of the males display blue scales (Fig. 3), at least at the time of emergence. Although the original description by Clench (1972, p. 37) records the male upperside as "uniform blackish brown when fresh," blue scales are conspicuous in these individuals, especially on veins R_1 to R_5 and the discal portions of M_3 , Cu_1 , and Cu_2 on the fore wings, and scattered in the discal area of the hind wings. The occurrence of blue scaling on the males may constitute a regional difference. The ground color above of the males varies from blackish gray to pale slate gray. The females vary greatly in ground color (whitish blue to fairly intense blue) and the amount of dark marking. There is no confusing any of these specimens, however, with any of the forms of *C. pseudargiolus* known to us.

To make preliminary comparisons of the caterpillars of *C. ebenina* and *C. pseudargiolus*, we obtained eggs and first instar larvae of the latter in two localities near Ann Arbor in Washtenaw Co., Michigan. They were readily found on the young inflorescences of Grey Dogwood, *Cornus racemosa* and Red Osier, *C. stolonifera* (Cornaceae), and Nannyberry, *Viburnum lentago* (Caprifoliaceae); the dates of collection were 8 and 22 May. We maintained the larvae under the same conditions as those of *C. ebenina* but kept them in a separate room to avoid any opportunity of possible escapees getting mixed up.

We did not make detailed comparisons of the larval morphology, but

certain differences were obvious. The final instar caterpillars of *C. ebenina* (Fig. 11) are considerably more uniform in color than those of *C. pseudargiolus*. They are pale whitish blue-green, with three slightly contrasting longitudinal stripes of yellowish white, two lateral and one dorsal. Between the dorsal and each lateral stripe is a line of yellow-white dots, and similar dots and dashes are scattered over the body. The caterpillars of *C. pseudargiolus*, as is well known, are more variable in ground color, ranging from pinkish or pale bronze to yellowish green; the pattern is much more conspicuously blotched as a rule. Earlier larval stages of the two species (young instars of *C. ebenina* shown in Figs. 7-10) are very similar in their uniform pale green color.

In both species the mature larvae are velvety because of elaborate stellate processes, each with a narrow and pointed filament arising from the center. In *C. ebenina* the filaments are only slightly curved and stand nearly erect. In *C. pseudargiolus* the filaments are more strongly curved and tend to be arched over such that they are distally nearly parallel to the body surface. This difference applies mainly to the more abundant, smaller filaments; larger ones in both species are more alike, only slightly curved and nearly erect.

Another difference between the larvae of the Dusky and Common Blues involves the use of their respective foodplants. Although larvae of *C. ebenina* occasionally feed upon the tiny embryonic floral primordia of *Aruncus*, the bulk of their feeding is upon the blade tissue between the major lateral veins of the leaflets. Their feeding produces characteristic elongated perforations in the blades; these persist when the leaflets have achieved their full size, and give valuable clues during late spring and summer for localities of the butterfly. Fig. 11 shows the characteristic perforations. The younger caterpillars were observed on the tops of the leaves more often than the older ones. Feeding between a pair of lateral veins usually begins near the midrib of the leaflet and progresses outward, but only rarely all the way to the margin and including it. Very large caterpillars in the last instar may eat major lateral veins.

In our experience the larvae of *C. pseudargiolus* feed primarily upon floral primordia. Their eggs and larvae are found in inflorescences. We tried moving larvae to leaves, but always, after eating a small amount, they would return to their floral clusters where they continued feeding. Larvae of *C. pseudargiolus* bite into the sides of the closed flower bud or the inferior ovary and eat the entire contents or leave certain parts (e.g., petals). The body of the caterpillar sits motionless on the floral pedicel or the side of the bud, and the extensible head is projected into

the cavity in the young flower to feed. From certain angles the larva appears headless.

Broods

Previous field experience of our own and others suggested either that *C. ebenina* is univoltine (in the Red River Gorge, flying from the second week of April to the first week of May), or else, if it has more than one brood, that adults of any later broods are so similar to those of *C. pseudargiolus* that they have not been recognized as distinct. The second laboratory brood is like the first brood. As it turned out, the vast majority of our pupae (Fig. 12) emerged within a week or two of pupation. Of those that failed to emerge and were kept until the following winter, only a few produced butterflies.

The first adult from our 18 April field collections of *C. ebenina* eggs emerged on 11 May. The first from our 2 May collections of eggs and young larvae emerged on 23 May. Emergence continued until 29 May, when it was stopped by placing the cultures in a coldroom from this date until 4 June to keep more butterflies from appearing while we were out of town. After we returned them to normal temperatures, emergence resumed on 5 June and continued to 12 June. A grand total of 175 butterflies in our laboratory cultures seemed to demonstrate that there is a second brood in the wild that follows closely upon the first, the second brood flying from the second week in May to the first or second week in June.

We therefore returned to the Red River Gorge to determine whether a second brood occurred in nature. The results of our survey were most unexpected. Loran D. Gibson visited there on 26 May and saw not a single *C. ebenina*, although many other butterfly species were seen (*in litt.*, 2 June 1976). We then reconnoitered the area on 4 June, when the butterflies should have been at their peak abundance, if there is a second brood in nature. We saw no *C. ebenina* despite the fact that *C. pseudargiolus* was common as well as 16 other species of butterflies. On 9 June, Amos H. Showalter searched the area and reported that "*C. pseudargiolus* was common, but no *ebenina*" (*in litt.*, 28 June).

After 13 June, the 28 pupae that remained in our cultures apparently went into dormancy, and no more butterflies emerged. At the end of June, therefore, we placed them in a coldroom at a temperature of 2°C and left them there until 22 December. We hope that by keeping them thus, in a set-up that we have used for "winterizing" fruits and seeds, we might avoid the destructive effects other workers have had with *C. pseudargiolus*, which involve either drying out or molding of the chrys-

alids. On 1 January 1977, two females emerged, one of which failed to expand its wings. Another female emerged on 4 January, and still another female failed to escape from the pupal skin. All the remaining pupae appeared to have died, eight of them having moldy surfaces and the rest having an unnatural brown color.

What can we conclude regarding the broods of *C. ebenina*? In the field we found no evidence for a second brood. If there is one, it must be in extremely low numbers, i.e., a small "partial" brood. Somehow the conditions of our laboratory cultures must have caused an abnormal eclosion without the customary prolonged dormancy period. Some diapause stimulus that effects *C. ebenina* must have been weak or missing under the conditions of our experiment, and thus only a small percentage of the chrysalids went into long-term dormancy.

Botany of the Foodplant

The colloquial name of the foodplant, *Aruncus dioicus*, may cause some confusion, since its name "Goat's-beard" is applied also to the unrelated *Tragopogon pratensis* L. in the Asteraceae, a naturalized weed from Europe. The generic name *Aruncus* comes from the Greek and means literally "goat's beard." It is a member of the Rosaceae and is a native eastern American plant of rich, mature forests. It is famous among United States' botanists as an illustration of convergent evolution, because superficially *A. dioicus* resembles closely the "False Goat's-beard," *Astilbe biternata*, of the Saxifragaceae. So closely do these plants resemble each other that they are regularly confused, even in herbaria. Ecologically the two look-alikes occupy almost identical niches, and they are both unusual among members of the mesophytic forest association in being dioecious (male and female flowers being borne upon separate plants). They are pollinated not by wind, which is the usual situation in dioecious plants, but rather by insects, mainly small Hymenoptera. The geographical range of *Aruncus dioicus* is shown in Fig. 10. The range of *Astilbe biternata* is much narrower, mainly in the mountains of North Carolina and adjacent parts of Virginia, W. Virginia, Kentucky, Tennessee, South Carolina, and Georgia. *Aruncus* overlaps it completely, so that students of *C. ebenina* must be warned of the danger of confusing the "True" with the "False" Goat's-beards in the area of their sympatry. Accordingly, we have prepared a comparison of the two in Table 1, the most obvious characters marked with asterisks. A line drawing of a mature specimen of *Aruncus* nearly 1½ m tall is reproduced in Fig. 1. The stage of growth when the plant serves as larval food for *C. ebenina* is shown in Fig. 2, corresponding to only the two bottom leaves and the lower

TABLE 1. Comparison of "True" and "False" Goat's-beards.

	<i>Aruncus dioicus</i>	<i>Astilbe biternatum</i>
*1. Stipules	Absent	Present
2. Terminal leaflet	Unlobed	3-lobed
3. Leaf base	Attenuate	Cordate (heart-shaped)
*4. Veins per leaflet	8-18 pairs	8 or less pairs
*5. Leaf and stem hairs	Absent	Abundant (glandular)
6. Marginal teeth	Convex	Acuminate
7. Sepals per flower	5	5
8. Petals per flower	5	0-5
9. Stamens per flower	15-20	8-10
*10. Carpels per flower	3-4	2

sixth of the drawing. The tissues upon which the caterpillars feed are soft, and the earliest instars feed upon the most embryonic parts. The plants grow rapidly and come into flower 5-7 weeks after the butterflies lays their eggs.

Both *Aruncus* and *Astilbe* have rather massive underground stems that produce large roots or root masses which hold the plants firmly in place on steep slopes (Fig. 3). Many buds are present at the ground level, and some of these may develop into shoots at the crown, producing clumps of as many as eight flowering shoots. Their spreading compound leaves fill in the space where they grow, presumably allowing little growth of other plants beneath them.

The Goat's-beards are most typical of rich, mesic woods, partly shaded roadsides, and sloping sides of streams and rivers. The ancient habitat was probably on steep eroding slopes and stream banks in dark forested areas, but man has stimulated its spread by creating new habitats where roads have been cut through the mesic forest. In a uniformly shaded forest stand only 10% of the plants may flower, but when released from the effects of low light levels, as on road cuts at the forest edge or steep, eroding stream banks, the populations may display up to 100% flowering. The plants require, however, relatively cool, moist conditions, and they exist almost exclusively upon north-facing slopes. *Aruncus* is known to occur as high as 5500' altitude in the mountains (Buncombe Co., N.C.), although the average occurrence throughout its range is considerably less than 2500'.

Would-be collectors of *C. ebenina* should seek the foregoing site conditions, with the following array of associated species (based upon studies of a number of *Aruncus* localities by Mellichamp 1976): woody plants—*Acer rubrum*, *A. saccharum*, *Aesculus octandra*, *Betula lenta*, *Carpinus caroliniana*, *Cornus florida*, *Fagus grandifolia*, *Lindera benzoin*,

Liriodendron tulipifera, and *Tilia americana*; herbs—*Adiantum pedatum*, *Athyrium filix-femina*, *Botrychium virginianum*, *Carex plantaginea*, *Cimicifuga racemosa*, *Geranium maculatum*, *Impatiens capensis*, *Laportea canadensis*, *Tiarella cordifolia*, and *Trillium* spp. The presence of a majority of these species, together with Wild Hydrangea, *Hydrangea arborescens*, given the topographical conditions cited, especially a north-facing slope, should lead to colonies of *Aruncus* and therefore *C. ebenina*.

Ranges of Plant and Butterfly

There is a remarkable correlation between the known localities where the butterfly has been found and the geographical distribution of *Aruncus dioicus*. Clench (1972) has already discussed doubtful records for *C. ebenina*, including New York City and southern Colorado. We should like to add to the list of doubtful records that of Blatchley in Wabash Co., Indiana (Clench, 1972, p. 41), unless an actual specimen is discovered. The "black male" he referred to could have been a melanistic male of *C. pseudargiolus*, a wind-blown stray of *C. ebenina*, or a mislabeled specimen. Clench mentions that Edwards had vaguely attributed the species to Tennessee and Georgia, although Clench himself had seen no specimens in these areas. It now seems very likely, as Clench (1972) suggested, that *C. ebenina* may turn up in both of those states.

Aruncus grows far to the west of the localities cited in earlier studies of *C. ebenina* (Clench, 1972; Wagner & Showalter, 1976), the westernmost documented records for which were all east of Cincinnati, Ohio, and Lexington, Kentucky. We can now report records in Illinois, Missouri, and Arkansas. Charles L. Remington took a fresh male south of Elsah, Jersey Co., Illinois, on 15 April 1942 (*in litt.*, 21 Jan. 1977). He found additional males in St. Louis Co., Missouri, in the late 1930's. Also, J. Richard Heitzman (*in litt.*, 14 July 1976) has informed us that he obtained by exchange "a male and a female taken 4 May 1924 at Creve Coeur Lake near St. Louis, St. Louis Co. There is no collector's name, but it should have been one of the active collectors of the day, probably Ernst Schwarz, E. P. Meiners, or H. I. O'Burne. All were active at the time and collected often at Creve Coeur." The dot shown in Fig. 10 for Arkansas is based upon a single male taken in Hickory Flat Hollow, Washington Co., on 2 April 1973 by Edward Gage. Gage writes (*in litt.*, Dec. 1976): "This male particularly stood out as it was flying about a mud puddle with several *C. argiolus* and *Everes comyntas*. . . . I immediately assumed that it was a melanic form and quickly collected it. The site was in close proximity to a draw or shallow canyon. About 50% of the immediate surrounding area is deciduous hardwood. . . . Can-

yons and woodland extend all around Beaver Lake from the collecting site."

CONCLUSIONS

Celastrina ebenina may have larval foodplants other than *Aruncus dioicus*. However, it should be noted that none of the unquestioned localities of this butterfly lies outside the known range of *Aruncus*. Furthermore, we now have good reason to believe that the abundant Common Blue, *C. pseudargiolus*, does not share the foodplant of the Dusky Blue, *C. ebenina*. Our experimental raising of eggs and young larvae on *Aruncus* from areas in which *C. pseudargiolus* is abundant revealed not a single specimen of that species. All were *C. ebenina*.

One reason for apparent rarity of *C. ebenina* in comparison with its near relative is that its geographical range is much more limited. Another is that it is probably monophagous rather than polyphagous. Its foodplant is confined to one habitat—north-facing, richly wooded, shaded slopes, so that the butterfly tends to be highly localized and colonial. The multiple foodplants of *C. pseudargiolus* occupy many habitats, and the butterfly is therefore practically ubiquitous.

Celastrina ebenina is probably often overlooked. The dull males in flight may suggest badly worn individuals of *C. pseudargiolus*. *Celastrina ebenina* tends to fly closer to the forest floor (a concomitant of its understory foodplant?), whereas *C. pseudargiolus* has a slow, up-and-down flight reaching the shrub and lower tree layer. The bright reflecting blue of *C. pseudargiolus* males plus their tremulous flight pattern through the woods at heights of roughly 2–10' make them especially visible. The females of *C. ebenina* resemble dull females of *C. pseudargiolus*, but they are even more localized than the males, rarely even visiting mud puddles, occurring rather in the herb layer of the forest in more or less checkered sunlight. We wonder how many collectors (including ourselves!) in the spring have overlooked *C. ebenina* while they focused instead on such critical genera as *Erynnis* and *Callophrys* as well as such widely advertised rarities as *Pieris virginicensis* and *Erora laeta*, both of which are now known to fly in association with *C. ebenina*.

If the conclusions of this research are correct, we predict that *C. ebenina* will be found not only in many new localities in the states from which it is already known, but, in addition, southern Indiana, eastern Tennessee, northern Georgia, western South Carolina, and western Maryland. To help achieve this, we propose the following formula:

1. Locate areas of rich mesophytic forest in rolling or mountainous country.

2. Follow roads or streams and find north-facing, cool, shaded forest slopes with some erosion or disturbance.

3. Look for plant associations including such trees and shrubs as *Hydrangea*, *Acer*, *Aesculus*, *Betula*, *Carpinus*, *Cornus*, *Fagus*, *Lindera*, *Liriodendron*, *Rhododendron*, and *Tilia* plus the majority of herbs given above.

4. Explore for large colonies of "Goat's-beard," *Aruncus dioicus*, the larval foodplant, especially on north-facing roadsides and streamside slopes.

5. Visit the area in April and early May in search of *C. ebenina*—males on muddy spots, females around the foodplant, and both sexes on Geranium flowers (careful!—they may be underneath the petals).

6. Or, if the weather is cloudy or rainy, search the young shoots of *Aruncus* for greenish blue, rough-surfaced eggs, and (or) pale green caterpillars, the latter evidenced by narrow perforations in the soft leaf tissue between the veins of young leaflets.

To sum up, our evidence thus far indicates that *Celastrina ebenina* is a "specialist," not a "generalist." When compared with *C. pseudargiolus*, it has a narrow range (not broad), one foodplant (not many), a single brood (not several), and an essentially uniform morphology (not many varieties and forms).

ACKNOWLEDGMENTS

We thank the following persons for their help in this project: J. M. Beitel, J. G. Bruce III, Robert P. Carr, D. J. Harvey, Loran D. Gibson, J. Richard Heitzman, Janice Glimn Lacy, Amos H. Showalter, Florence S. Wagner, and K. S. Walter. We are especially grateful to Harry K. Clench for his encouragement and critical advice.

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STUDIES ON RESTINGA BUTTERFLIES. II. NOTES ON THE POPULATION STRUCTURE OF *MENANDER FELSINA* (RIODINIDAE)

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ABSTRACT. The objective of the study was to describe various aspects of the adult behaviour and population dynamics of the riodinid butterfly *Menander felsina* (Hew). The conclusions were based on four years of field observations and a marking-recapture study conducted over a period of 15 weeks.

The population was characterized by low intensive and extensive frequencies (rarity in numbers and space respectively), characteristics shared by many other forest riodinid species. *M. felsina* maintained constant population levels of about 19 individuals over the 15 week marking-recapture period, due to 1) longevity above that of most holarctic lycaenids, 2) low egg laying frequency both in time and space, and 3) male territoriality, which results in older males doing most of the mating. Limited adult and larval food sources were discounted as an explanation.

The population was found to be distributed in small groups or colonies near food plant localities. The reasons for this were the low extensive distribution of foodplants coupled with high female vagility. Depending upon conditions at each foodplant locality, such as predation and exposure to the elements, each colony could become extinct, only to be reestablished by another wandering female.

Studies on the ecology of neotropical butterflies to date have been concerned for the most part with the larger species such as heliconiines (Crane, 1955, 1957; Turner, 1971; Ehrlich & Gilbert, 1973), nymphalines (Benson & Emmel, 1973; Young, 1972), and papilionids (Cook *et al.*, 1971). Smaller butterflies such as riodinids have received only superficial treatment, mainly consisting of scattered notes on observed habits and population density. Early writers such as Bates (1864) and Seitz (1913) made reference to the rarity of individuals and the great numbers of species that characterize neotropical riodinids. This has been confirmed statistically by Ebert (1969), who used the terms low extensive and intensive frequency to denote the rarity of populations and individuals, respectively. However, there has been no attempt to explain the mechanism(s) involved in maintaining populations in spite of such low intensive and extensive frequencies. The opportunity to study this phenomenon was provided to me by the discovery of a reasonably large colony of *Menander felsina* (Hew.) near Rio de Janeiro, Brazil. Whereas the ecology of this butterfly resembles closely that of other forest-dwelling but less common species, it also provides the basis for conclusions of a general nature applicable to other members of this group.

The purpose of this paper is to describe the adult behavior of *M. felsina* in connection with feeding, male patrolling, and mating. The

results of a marking-recapture program are presented with an analysis and discussion of the population parameters.

METHODS

The observations that form the basis of this study were gathered over a period of more than 4 years at Pedra de Itauna, an area near the coast west of Rio de Janeiro, Brazil. The vegetation is typical of the restinga (coastal dune community) described in detail elsewhere (Callaghan, 1977). The area for the mark-recapture study was a trail some 125 m in length just inside the south (seaward) side of the low woods surrounding the Itauna Rock. Because of the density of the brush, little collecting was possible elsewhere in the forest. The mark-recapture project took place over a 14-week period, from 18 July–15 November 1973. Marking was done every weekend except for five near the end, which were lost as a result of inclement weather. An average of ca. 5 h collecting (900–1400 hrs) per day was devoted to the experiment on study days. Individuals, once captured, received a predetermined mark that indicated the day and were immediately released at the same spot. Occasionally, a butterfly would show signs of shock after marking by fluttering to the ground, in which case it was killed and eliminated from the experiment. For analyzing the data, the Fisher and Ford method (Fisher & Ford, 1947) was used because of the relatively small sample sizes.

RESULTS

General Behavior: Feeding, Mating, and Patrolling

Menander felsina inhabit exclusively the low woods and nearby flats on the seaward side of the forested areas. They prefer open habitats such as trails and small clearings in the woods, shunning completely the deep shade found in the higher forests. Yet, they are one of the few butterflies that fly on cloudy days, albeit in smaller numbers than on sunny ones. Both sexes can be found sunning in the early morning hours with wings outspread on the upper surfaces of leaves 2–3 m above the ground. When disturbed, they fly off with a rapid, jerky flight, circling a few times before settling, wings outspread on the undersides of leaves not far from where they departed. After a few minutes they sometimes return to the same spot. When resting, they appear to thermoregulate, raising the wings to sharper angles depending on the intensity of the sun's rays.

Group feeding takes place in the morning hours from 800–1100, and to a lesser degree in the late afternoon. The *M. felsina* will visit prac-

tically any plant that happens to be in bloom in the habitat, often becoming so "engrossed" in feeding that they can be removed with forceps. Males and females feed together, the latter being found commonly only at this time.

Starting ca. 1230 hours, males begin taking up positions on the edges of trails and clearings to await females. They sit motionless for long periods on the upper or undersurfaces of leaves from 0.2–2 m above the ground with their abdomens slightly raised. Males seldom leave their perches to investigate other species of butterflies. The only ones investigated were small white pierids (*Eurema* sp.), which to some extent resemble *M. felsina* in flight. Larger butterflies and skippers are completely ignored, which indicates that sight plays a role in the recognition of rivals or mates. This activity continues until ca. 1500. This behavior is in contrast to the habits of lycaenids (Powell, 1968; Scott, 1974) and skippers (MacNeill, 1964). In these cases the males would investigate any object flying past them, including small rocks (MacNeill, 1964).

To determine the extent to which spacing occurs among males, a section of trail some 20 m long was observed on three occasions. In the middle of this area is an opening in the woods that faces outward toward the knee-high vegetation of the flats. Here, an older, slightly worn male took up a station at 1255. From time to time he would take off, flying around in an area some 5×3 m and perching for a few minutes on various plants within this area. At 1326, two fresh males moved into the study area, taking up positions to the right and left of the older male. When one of these flew near the older male, the latter rose up, flew around in circles with the other for a few seconds, then returned to his original spot, the fresh male alighting a few yards outside the area of the older male. At 1405, a female alighted on the outward side of the older male's area. He immediately flew over to the female, who took off, and followed her out onto the flats. A half hour later, he had not returned, nor had other females appeared in the areas of the fresh males. The next day at the same time, the same older male was again observed in the same area.

On another occasion only fresh males were observed. They showed less exclusiveness with regard to patrolling areas than the older males. Another male passing nearby would sometimes be engaged in a circular mutual chase, but both individuals would then settle down on leaves sometimes only a meter apart. Once a male left an area, another would often move in. During the observation periods, no females were seen entering the fresh males' areas.

TABLE 2. Type A data trellis derived from data in Table 1. Units under "Date of Marking" refer to marks and not animals.

Date	Captured	Released	Date of Marking								
			18	1	9	17	24	7	14	20	15
18 Aug.	22	22									
1 Sept.	14	14	2								
9 Sept.	15	15	2	4							
17 Sept.	17	17	1	4	8						
24 Sept.	15	15		1		1					
7 Oct.	19	19			1		2				
14 Oct.	7 ¹	7 ¹					1				
20 Oct.	24	24						5	3		
15 Nov.	22	22							2	5	

¹ Low captures due to inclement weather.

On one occasion, a complete courting sequence was observed. About 1416, a female alighted on a leaf, wings outspread ca. 1 m from a perched male, who immediately flew around her several times, then alighted and, with wings moving slowly up and down, walked to a face to face position. There they remained for ca. 30 sec. Then, the female walked around to the underside of the leaf, the male followed, and copulation was initiated. This lasted for ca. 22 min. On another occasion, a pair discovered *in copula* under a leaf remained so for 8 min before breaking off. Sexual activity continues until late in life. On 15 November 1973, a male that had been marked three weeks previously was found *in copula* with a freshly emerged female. Finally, mating appears to be done by older territorial males since, of the three cases observed, two involved males that had been previously marked.

POPULATION SIZE AND MORTALITY

Tables 1 and 2 show the basic marking and recapture data gathered during the study, after Sheppard & Bishop (1973). It is instructive to note that few individuals were captured more than once, which indicates that collecting was not very efficient over time. Low captures on 14 October were due to rainy weather. The survival rate (Fisher & Ford, 1947) was 0.45 per week or ca. 0.91 per day. The average life span was 1.82 weeks by the formula $E = \frac{1}{1 - \text{survival rate}}$, which as-

sumes that all deaths occur just before sampling. Potential survival is up to 5 weeks in the field, as confirmed by a recaptured female. Observed field survival for males is up to 4 weeks. When the Lincoln index modified by Bailey (1952) is applied to the study data, the weekly

TABLE 3. Population composition over time of new and recaptured butterflies, considering all animals captured and recaptured before and after a determined date to constitute part of the population even though they were not captured on that date.

Date	Total	New	%	Recaptures	%
18 Aug.	22	22	100	—	—
1 Sept.	17	12	71	5	29
9 Sept.	20	9	45	11	55
17 Sept.	19	4	21	15	79
24 Sept.	16	13	81	3	19
7 Oct.	23	19	82	4	18
14 Oct.	11	6	54	5	46
20 Oct.	25	16	64	9	36
15 Nov.	22	15	68	7	31
Average	19.4	10.4	—	7.4	—
Standard Error	$\pm 22.6\%$	$\pm 49.2\%$	—	$\pm 42.4\%$	—

estimates of total population size show great variation as a result of the large differences in recaptures from one sampling to the next.

These fluctuations were felt to be more due to inaccessibility of individuals because of the thick brush on either side of the trail than to changes in the population level. Therefore, to make the capture data more realistic a third table was mounted assuming that those animals captured in week one and recaptured in week three, for example, formed part of the population in week two even though they were not captured at that time. In Table 1 we see that on 18 August, 22 butterflies were marked and released of which five were later recaptured: two on 1 September, two others on the 9th, and one on 19 September. On the 1st, at least three butterflies were not captured.

Therefore, rather than a total of 14 for that date, we have 17 which we know formed part of the population at that time: 12 new plus 2 recaptured plus 3 which were recaptured at later dates. The numbers thus derived were entered in Table 3. The procedure was conducted for each capture period during the study.

This results in considerably smoother total capture figures, which show that if allowance is made for inefficiency in collecting, the estimates of numbers of individuals in the study area was quite stable over the 14-week period (Table 3) with a mean of 19.4 individuals and a standard error of 4.4 or $\pm 22.6\%$. More consistent results can be obtained by eliminating data for 14 October. When efforts were made to capture all the *M. felsina* in the study area—22 July 1973 and 6 June 1974—21 and 22 individuals were recorded, respectively, which again suggests that the number of *M. felsina* in the study area remains stable over long periods with a low number of individuals.

Sex ratio data gathered during the study were unsatisfactory as a result of the similar appearance and behavior of males and females, except during oviposition and territorial displays. Because of the delicate nature of these butterflies, they had to be kept in the net during marking and afterwards immediately released. This prevented detailed examination. Females, however, were a small minority of all captured. On the two occasions referred to above, 19 males were captured each time with 2 and 3 females, respectively. The reason is that the females entered the study area sporadically only for mating and feeding, thus not being as accessible as the males. The number of females caught under these circumstances is not truly representative of the female population; thus, for the purpose of this study, males and females were considered together.

DISCUSSION AND CONCLUSIONS

As noted above, tropical butterfly populations, especially those of theclids and riodinids, are characterized by low intensive and extensive frequencies. The data from the marking-recapture program and other observations on the *M. felsina* population permits a number of suggestions as to why this is so.

Low Intensive Frequency

Low intensive frequency means that an animal is represented by a small number of individuals in a given population. As shown by the recapture data, the number of *M. felsina* frequenting the study area remained low and fairly constant for long periods. Other students have made similar observations on neotropical butterfly populations. Benson & Emmel (1973) observed a roost of *Marpesia berania* (Hewitson) in Costa Rica that maintained constant equilibrium of population size for more than 3 months because of constant rates of recruitment and mortality. Ehrlich & Gilbert (1973) recorded a similar structure for *Heliconius ethilla* Godt in Trinidad over a period of 2 years, as did Young (1972) for *Siproeta epaphus* (Latreille) in Costa Rica. Why do these populations have an equilibrium level and what is the mechanism that enables them to maintain it? Ehrlich & Gilbert (1973) explain the constant population level in *H. ethilla* through the constant recruitment of new adults over time which equals mortality. This was thought to be due to unvarying predator pressure on the immatures and not because of a lack of foodplant, which was quite common in the habitat. The other factor was limited adult nectar resources, which controlled egg production, thereby regulating the production of immatures. Young

(1972) in his study of *S. epaphus* likewise found that egg and adult numbers remained constant throughout the study period. As a mechanism, he suggested low fecundity and low adult vagility as well as the sheltered nature of the forest understory community. Both studies discount outmigration as a factor.

My observations on *M. felsina* allow the following conclusions to be made. First, neither foodplant nor nectar availability appeared to be a limiting factor. The larval damage was always small compared with the amount of foodplant available, showing little pressure on foodplant resources. The adult's preference for nearly anything that is in bloom and its willingness to travel good distances eliminates lack of adult nectar sources as a possibility. The factors that appear to be most significant are low egg-laying frequency, increased longevity, and male spacing.

Low egg-laying frequency was observed on several occasions. The maximum number of eggs seen laid in any one afternoon by the same female was four, these being laid singly and widely dispersed on the foodplant (Callaghan, 1977). The results of this were shown in the low numbers of widely separated larvae in all instars that could be found on the same foodplant. Pupation and emergence were likewise staggered, meaning a fairly even flow of adults over time. Since the larvae were attended and protected by ants (Callaghan, 1977), predation was kept down to a minimum and thus did not appear to be a significant factor as it was in the case of *H. ethilla* (Ehrlich & Gilbert, 1973). For *M. felsina*, then, the low frequency of oviposition assures the low intensive frequency of its populations. Why egg production should be low could not be determined during the course of the present study.

Another factor is longevity. The 1.82 weeks observed for *M. felsina* is high when compared with holarctic butterflies, but low with respect to those tropical nymphalines that have been studied. Scott (1974) reported an average life span of 4.2 days of *Lycaena arota* Bois with a potential of 8 days. Labine (1968), Turner (1971), and Cook *et al.* (1971) reported the life expectancy after marking for 6 holarctic species in the field as from 2.8–12.1 days. Powell (1968) gave a maximum of 16 days for *Incisalia iroides* (Boisduval). On the other hand, Benson & Emmel (1973) demonstrated that the neotropical nymphaline *Marpesia berania* has an average longevity of 43.9 days with a potential of at least 157. Heliconids are especially long lived. Benson (1972) reported *Heliconius erato petiverana* Doubleday in Costa Rica with average observed longevity of 52 days and an individual alive 6 months after

marking. Turner (1971) and Ehrlich & Gilbert (1973) reported similar results. Greater longevity ensures low intensive frequency and is of considerable selective value in the tropics since it enables the widespread dispersal of eggs in both space and time, which may diminish parasitism and ensure a larger number of offspring reaching maturity (Benson & Emmel, 1973). Also, having individuals in all stages of development would permit survival of a natural disaster that might eliminate one stage but not the others. The causes of adult mortality of *M. felsina* are not precisely known, since no actual predation or other forms of natural mortality were observed during the study. However, potential predation exists in the form of lizards, spiders, ants, and birds. Rapid flight and hiding beneath leaves are two methods used by adult *M. felsina* and many other riodinids to avoid predation. On the other hand, its fairly sedentary habits might mean greater predator pressure and lower survival rate for *M. felsina* than for heliconines and nymphalines, which enjoy mimicry, distastefulness, and/or strong flight. Lower survival would be more likely true for males because of their conspicuous behavior.

Finally, male spacing seems to select for longevity, since older males have been observed to be more aggressive and fixed to their habitual areas and thus are easily able to drive off younger, more inexperienced newcomers. The result is that females appearing at the rendezvous area will be more likely to mate with strong, long-lived males. This in turn assures longer-lived offspring, which can effectively distribute their eggs widely in space and time. These three factors combined, then, might provide for the perpetuation of the low intensive frequencies observed in the *M. felsina* population. Although to date other forest riodinids have not been studied in such detail, I suspect that their low intensive frequencies may be explained on much the same basis.

Low Extensive Frequencies

Low extensive frequency means that populations are found rarely within a given faunistic region. This is the case with *M. felsina* as well as other forest riodinids. The key factor here in the case of *M. felsina* is foodplant distribution. Individuals of *Norantea brasiliensis* Choisy (Marcgraviaceae), the *M. felsina* foodplant, are widely and sparingly distributed on the restinga, but this does not prevent their being visited by ovipositing females.

There is a tendency on the part of the newly emerging butterflies to establish a colony at a suitable locality near the site of their foodplant. This was observed on several occasions, the most notable of which was

when two males were seen engaging in patrolling behavior on a small clump of bushes near a foodplant some 500 m from the main colony. These same two individuals were there one week later, a little bit worn but still recognizable. Before the next visit, they had disappeared and no others had taken their place. On the nearby foodplant, larvae were discovered in various instars. I did not observe any other case of actual colonization occurring on that particular clump of bushes. Undoubtedly, this attempt failed as a result of the rather harsh, unsheltered conditions in that particular section of the restinga. Females, then, are the colonizers for *M. felsina*, traveling considerable distances many times in search of foodplants on which to lay their eggs.

This phenomenon has been recorded indirectly with other riodinid butterflies. On numerous occasions a single butterfly will be encountered at a particular place and time, whereas subsequent visits under comparable conditions will fail to turn up additional specimens. In the same woods as the *M. felsina* habitat, a single male *Calydna lusca* (Geyer) was captured on 18 July 1973. On 7 July 1972, a male and female *Nymphidium lisimon attenuatum* Stichel were taken and a single female *Leucochimona philemon* (Cramer) was taken on 7 July 1973. Before and since, 46 collecting days over 4 years have failed to reveal additional examples from this small wood. The best explanation is that the females are very vagile, always on the move searching for new foodplant localities. Similar conclusions have been reached by other students of tropical riodinids. Ebert (1969) mentions that little species such as riodinids "migrate continuously within a great area of favorable biotypes. . . ."

Finally, the question arises concerning the barriers that female riodinids will cross in their movement. In the case of *M. felsina*, open flat areas do not appear to provide a serious obstacle, although this might be expected because of their preference for a low forest habitat. Observations on deep forest riodinids are few but significant. On 19 January 1975, a lone female *Nymphidium mantus* (Cramer) was observed passing through dry secondary shrub near Linhares, Espirito Santo, Brazil, an area very different from its normal habitat in the deep forest near the edges of swamps. Water does not appear to be a significant barrier since many riodinid populations on either side of large rivers such as the Amazon are virtually indistinguishable (Callaghan, in prep.).

SUMMARY

The results of the marking-recapture and observations of adult behavior allow a number of conclusions to be drawn with respect to the

population structure of the neotropical riordinid butterfly *M. felsina*. It was found that this butterfly exhibits the structure common to most forest butterflies, that of low intensive and extensive frequencies. The reasons for the former are low egg-laying frequency, longevity, and male spacing. The latter was explained by a combination of high female vagility and low intensive and extensive foodplant distribution, which lead to the establishment of new colonies by females at widely dispersed foodplant localities. Depending on conditions at these localities, such as parasitism and exposure to the weather, the colony may become extinct only later to be reestablished by another wandering female. It is suggested that similar population structures for other neotropical forest butterflies, particularly riordinids, may be explained on this same basis.

ACKNOWLEDGMENTS

I wish to thank Drs. Woodruff Benson and Keith Brown for making many helpful comments on the manuscript and the former especially for his helpful discussion and encouragement during the initial phases of the field work. To Dr. Alfredo de Rego Barros my thanks for use of the facilities of the Museu Nacional do Rio de Janeiro.

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Journal of the Lepidopterists' Society
32(1), 1978, 48

THE INTERNATIONAL CODE OF ZOOLOGICAL NOMENCLATURE

The draft third edition of the International Code of Zoological Nomenclature is now available for comment by zoologists. Copies may be obtained (price £2.50 surface mail, £5.00 air mail) from the Publications Officer, International Trust for Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London SW7 5BD, U.K. Comments should be sent as soon as possible, and in any case before 30 November 1978, to the Secretary, International Commission on Zoological Nomenclature, at the above address.

A paper explaining the major changes proposed by the Commission's Editorial Committee to the existing Code has been published in the *Bulletin of Zoological Nomenclature*, vol. 34, part 3. Copies may be obtained (price 50p) from the same address as copies of the draft Code.

AN ANALYSIS OF THE HELIOTHIDINE TYPES (NOCTUIDAE) OF HERMAN STRECKER WITH LECTOTYPE DESIGNATIONS

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ABSTRACT. The authenticity of the nominal type specimens of species of Heliothidinae described by Herman Strecker is evaluated. A number of the nominal type specimens are judged to be spurious. Lectotypes for the following Strecker species are selected: *Schinia approximata*, *Schinia dolosa*, *Heliothis fastidiosa*, *Schinia labe*, *Schinia lora*, and *Schinia pyraloides*.

In anticipation of future revisionary work on the Heliothidinae I took the opportunity in October of 1976 to examine Herman Strecker's type material belonging to this subfamily at the Field Museum of Natural History in Chicago. Strecker's species names have always presented a problem to Lepidopterists, firstly because his original descriptions were often very brief, and secondly because he evidently had the habit of augmenting or replacing his original type series. Thus, although *Heliothis regia* was described from a single specimen, there are now six specimens each labelled in his hand as "type" of *regia*.

In the earlier years of his career, Strecker evidently had no type concept, or at least a very nebulous one. As a result, many of the specimens on which he based his early original descriptions must have been either destroyed or misplaced. In later years, however, with increasing awareness of the value of type specimens, Strecker presumably tried to rectify his earlier laxity by labelling specimens other than the "originals" as his types.

If such substitutions can be demonstrated, then obviously the spurious types have no status under the "Rules." Nevertheless such pseudotypes do have value in indicating Strecker's concept of his species in the maturity of his later years, and should be considered in any subsequent neotype selection procedures if these are found to be necessary. At the present time the Strecker Collection is housed as a separate entity within the collections of the Field Museum of Natural History, and Strecker's arrangement of species and his hand-printed labels have been retained. In my discussion of type specimens which follows, the species names are arranged alphabetically.

Rhododipsa aden Strecker

Strecker, 1898, p. 11.

The original description of *aden* was based on a single specimen. The male labelled as "original type" in the Strecker collection matches the original descrip-

tion well and is evidently the one on which Strecker based his description. It is labelled as follows: "Col."; "384"; "S. Aden, Orig. Type". There is a major piece of the left hind wing broken off and the anal angle of the right front wing is missing. A genitalic slide (no. FM Hel 1) has been prepared from the holotype.

Schinia approximata Strecker

Strecker, 1898, p. 10.

This species was described on the basis of three specimens collected by Boll near Dallas, Texas. The three females labelled as "original types" match the original description well and are assumed to be authentic. Because of its superior condition the specimen numbered 76 is hereby selected as lectotype; it is labelled as follows: "76", "S. approximata, 374, Orig. Types". A genitalic slide (no. FM Hel 2) has been prepared from the lectotype.

Schinia ar Strecker

Strecker, 1898, p. 10.

The single male in the Strecker Collection labelled as "original type" matches the original description well, and is evidently the one on which the name was based. The specimen is labelled as follows: "371"; "S. ar, 371, Orig. Type". A genitalic slide (no. FM Hel 3) has been prepared from the holotype which is in excellent condition.

Schinia dolosa Strecker

Strecker, 1898, p. 9.

The original description was based on two specimens taken near San Antonio by Boll. The two males in the Strecker Collection labelled as "original types" are evidently authentic. I hereby select the slightly larger specimen as lectotype; it is labelled as follows: "tex"; "S. Dolosa, Orig. Type". A genitalic slide (no. FM Hel 3) has been prepared from the specimen.

Heliothis fastidiosa Strecker

Strecker, 1876, p. 121.

The original description of *fastidiosa* was based upon two specimens collected by Boll in Texas. The two males in the Strecker Collection match the original description well and undoubtedly represent the specimens on which it was based. I hereby select the smaller specimen bearing the individual "31" label as lectotype. The specimen is labelled as follows: "31"; "S. Fastidiosa, 31, Orig. Types". A genitalic slide (no. FM Hel 5) has been prepared from the lectotype.

Heliothis gloriosa Strecker

Strecker, 1877, p. 132.

A single specimen in the Strecker Collection is labelled as "original type" and this is evidently the one on which the original description was based. The specimen, a female, is in excellent condition except for lacking a portion of the right antenna. It expands $1\frac{7}{16}$ " and is labelled as follows: "18"; "S. gloriosa Orig. Type". A genitalic slide (no. FM Hel 6) has been prepared from the holotype.

Schinia hanga Strecker

Strecker, 1898, p. 9.

The species was described on the basis of one specimen collected by Boll at Dallas, Texas. The male in the Strecker Collection labelled as "original type" is

evidently this specimen. It expands $1\frac{1}{8}$ " and is labelled as follows: "70"; "393"; "S. Hanga, Orig. Type". A genitalic slide (no. FM Hel 7) has been prepared from the holotype, which is in excellent condition.

Heliothis imperspicua Strecker

Strecker, 1876, p. 122.

The original description of *imperspicua* was based upon a single specimen, bearing the number 53, which was collected in Texas by Boll. There are two specimens in the Strecker Collection each labelled as "original type" but these are evidently both spurious. One specimen is labelled as having been collected in Colorado; the other is without a locality label and bears the number "49". Neither specimen differs from the rather generalized original description in any striking detail. The true type of *imperspicua* must be presumed lost.

Heliothis inclara Strecker

Strecker, 1876, p. 122.

The original description was evidently based upon a single specimen collected by Boll in Texas, which was numbered 46. There are now two specimens in the Strecker Collection labelled as "original types". One of these bears the number 78 and is considerably smaller than the specimen cited in the original description. The other specimen is without collection number but corresponds well with the original description and may be the true type.

Schinia labe Strecker

Strecker, 1898, p. 10.

The original description of *labe* was based upon two specimens collected at Dallas, Texas by Boll. The two specimens in the Strecker Collection labelled as "original types" are apparently these. I hereby select the smallest of the two, which bears a separate "372" label, as lectotype. The lectotype is a male expanding slightly less than $\frac{3}{4}$ " and is labelled as follows: "372"; "S. Labe, 372, Orig. Types". A genitalic slide (FM Hel 10) has been prepared from the specimen.

Heliothis lanul Strecker

Strecker, 1877, p. 132.

There is a single male in the Strecker Collection labelled as "original type" and this is evidently the specimen on which the original description was based. There is no locality data indicated in the original description nor on the specimen. The holotype is labeled as follows: "85"; "S. Lanul, 85., Orig. Type". A genitalic slide (no. FM Hel 11) has been prepared from the type.

Schinia lora Strecker

Strecker, 1898, p. 10.

The original description of *lora* was based on three specimens, two from Boll collected near Dallas, Texas, and one from Heiligbrodt at Bastrop, Texas. Only two specimens in the Strecker Collection are labelled as "original types" and these are apparently authentic. There is another, unlabelled specimen in the collection which may represent the third specimen of the type series. Of the two specimens labelled as "original types" I hereby select the specimen with the separate "73" label as lectotype. The lectotype is a male in generally good condition which bears the following labels "73"; "373"; "S. Lora, 373, Orig. Types". A genitalic slide (no. FM Hel 12) has been prepared from the lectotype.

Schinia neglecta Strecker

Strecker, 1898, p. 10.

The single specimen labelled as "original type" in the Strecker Collection matches the original description well and is evidently the one on which the name *neglecta* was based. According to the original description the holotype was collected at Loveland, Colorado. The specimen is a female, expands 1", and bears the following labels: "Col."; "377"; "S. Neglecta 377., Orig. Type". A genitalic slide (no. FM Hel 14) has been prepared from the holotype.

Heliothis nubila Strecker

Strecker, 1876, p. 122.

Strecker's original description of *nubila* was evidently based on a single specimen taken in Texas by Boll (number 48). There are two specimens in the Strecker Collection labelled as "original types". Neither of these matches the original description very well, there being no red shading on the underside of the wings, and both are numbered "72" rather than "48". I consider these specimens to be spurious; the three types must be presumed lost.

Schinia obscurata Strecker

Strecker, 1898, p. 10.

The single specimen labelled as original type of *obscurata* in the Strecker Collection is obviously the one on which the original description was based. The holotype is in good condition except for having a notch in the left forewing. The female specimen is labelled as follows: "St. Vincent, Pa."; "378"; "S. Obscurata, 378, Orig. Type". A genitalic slide (no. FM Hel 15) has been prepared from the specimen.

Schinia pyraloides Strecker

Strecker, 1898, p. 9.

The four specimens on which the original description of *pyraloides* was based are in the Strecker Collection and labelled as "original types". The type series was taken at Glenwood Springs, Colorado by Bruce. I hereby select the male specimen with the individual "Col." label as lectotype. The specimen is in generally good condition except for lacking most of the left antenna and having a slit in the right hind wing. The lectotype is labelled as follows: "Col."; "S. Pyraloides, Orig. Type, Colorado". A genitalic slide (no. FM Hel 16) has been prepared from the specimen.

Heliothis regia Strecker

Strecker, 1876, p. 121.

So far as can be determined from the original description, the name *regia* was based upon a single specimen. There are, however, six specimens in the Strecker Collection labelled as "type". According to the original description the holotype was taken in Texas by Boll but none of the six nominal "types" bears a locality label. I have compared each of the specimens with the original description and one female matches it very well, and I construe this to be the true type. It is labelled as follows: "S. Regia, Type". A genitalic slide (no. FM Hel 17) has been prepared from the holotype.

Heliothis rubiginosa Strecker

Strecker, 1876, p. 122.

Strecker's description of *rubiginosa* was evidently based upon a single specimen taken in Texas by Boll; there are now six specimens, each labelled as "Type" in the

Strecker Collection. None of these, however, bear the "50" label mentioned in the original description. One of them, a male, matches the original description well and may represent the true type but the evidence is insufficient to make a definitive judgement.

Heliothis siren Strecker

Strecker, 1876, p. 122.

Strecker's original description of *siren* was evidently based on a single specimen collected by Boll in Texas. There are now two specimens in the Strecker Collection labelled as "original type" but neither of these bears the "45" label mentioned in the original description. One of the two is without number label and the other bears an "80" label. The unnumbered specimen matches the original description well and may represent the true type but there is no way of establishing this with certainty.

Heliothis spectanda Strecker

Strecker, 1876, p. 122.

The original description of *spectanda* was based upon a single specimen taken in Texas by Boll. When the Strecker Collection was examined, no specimen labelled as type of *spectanda* was found. There was, however, a specimen in the series of *Heliothis virescens* bearing the number "52" which was cited in the original description as belonging to the type. The specimen matches the original description very well and I construe it to be the holotype. A genitalic slide (no. FM Hel 20) has been prepared from the specimen which is a female.

Heliothis sulmala Strecker

Strecker, 1878, p. 1862.

The original description of *sulmala* was based upon a single male taken at Pagosa Springs (Colorado). Strecker evidently mislaid the specimen because it was found in 1939 in a drawer of miscellaneous moths; it lacks Strecker's characteristic type label. The specimen matches the original description very well, however, and I construe it to be the holotype. The specimen is labelled as follows: "*Heliothis Sulmala* Streck., Pagosa Springs Col., (Orig. Type), McCauley, Found (1939) in a drawer with misc. moths." A genitalic slide (no. FM Hel 21) has been prepared from the holotype.

Schinia tanena Strecker

Strecker, 1898, p. 10.

Strecker described *tanena* on the basis of a single specimen taken at Bastrop, Texas by Heiligbrodt. There is a single male in the Strecker Collection labelled as "type" and there is no reason to doubt its authenticity. The specimen is labelled as follows: "tex"; "380"; "S Tanena, 380, Orig. Type". A genitalic slide (no. FM Hel 22) has been prepared from the holotype.

Schinia ultima Strecker

Strecker, 1876, p. 122.

The original description of *ultima* was evidently based upon a single specimen taken in Texas by Boll. There are two specimens labelled as "original type" in the Strecker Collection, but both specimens bear the number "71" rather than the "49" indicated in the original description and both specimens differ from the original description in several details. I do not consider either specimen to represent the holotype, and the latter must be presumed lost.

ACKNOWLEDGMENTS

I appreciate the cordial co-operation of Dr. Rupert Wenzel, Chairman of the Department of Zoology, and Dr. Eric Smith of the Division of Insects, during my visit to the Field Museum of Natural History.

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 32(1), 1978, 54

Letter to the editor:

A Comment on Monarchs and a "Tragedy of the Commons" in Science

When the paper by Urquhart & Urquhart appeared in this journal (1976, Vol. 30: 153-158), I sat down and wrote a letter criticizing the editorial policy of allowing an observation to be published without providing sufficient information to allow verification by other biologists working with *Lepidoptera*.

While I shared the fear that publication of the exact locale of the Mexican roost would possibly endanger it, I felt that the authors should have at the very least volunteered to disclose the site to responsible qualified scientists researching monarch biology.

Subsequent events have made me regret not sending in my original comment. Incredibly, a scientist of international reputation, Lincoln Brower, was denied the locality information by Professor Urquhart. I do not consider such secrecy to be in the spirit of modern science, nor necessary in this particular instance.

Anyone familiar with Brower's body of work on the monarch would not question his scientific stature. Anyone who has seen his environmental film on the Connecticut River System cannot doubt his sensitivity to ecological problems.

We all respect the effort that Professor Urquhart has put into studying monarch migration. That does not, however, give him territorial rights over monarch roosting areas or free him from the scientific responsibility of allowing other scientists to verify his results.

Much of the controversy and ill will which apparently has followed L. Brower's independent visit to the Mexican monarch roosting area might have been avoided had the study of the monarch proceeded as unselfish science rather than a race for glory in glossy magazines.

In the future I would hope that this journal will insist that authors be willing to disclose their study sites to responsible colleagues.

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ATOPOTHOURES A. BLANCHARD: A SYNONYM OF GOYA RAGONOT (PYRALIDAE)

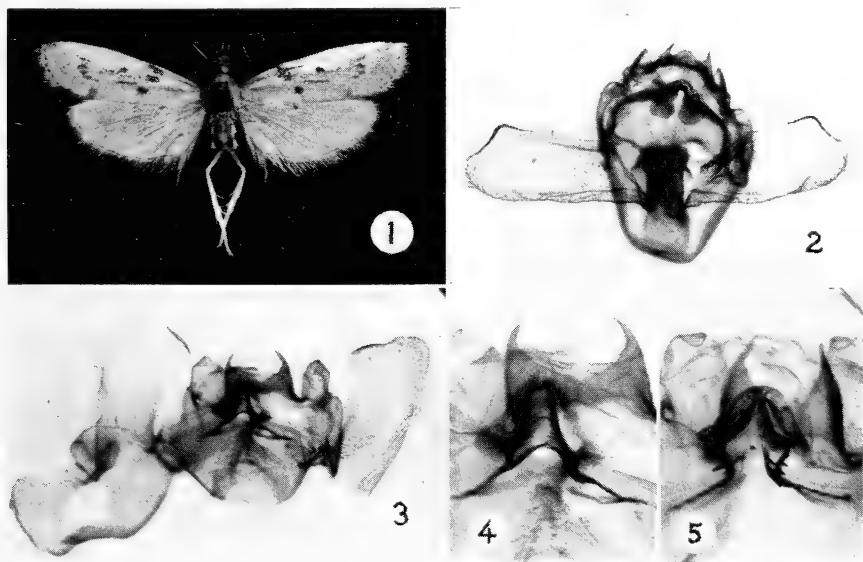
A. BLANCHARD

P.O. Box 20304, Houston, Texas 77025

ABSTRACT. *Atopothoures ovaliger* A. Blanchard becomes *Goya ovaliger* (A. Blanchard), close to, but different from *Goya stictella* Hampson.

Karan and Jay Shaffer, my wife and I went collecting, 17-24 May 1977, at the Welder Wildlife Foundation Refuge, near Sinton, Texas. Dr. Shaffer made a special effort to collect Peoriines and was well satisfied with the results of this trip. On their way back home the Shaffers spent an afternoon with us at Houston, so that he could examine my collection of Peoriines. This is when he discovered that what I had unfortunately described as *Atopothoures ovaliger* (Blanchard, 1975) should have gone under the genus *Goya* Ragonot.

The male genitalia of *G. ovaliger* are extremely close to those of *G. stictella* Hampson which is not too uncommon in Texas, but the two



Figs. 1-5. *Goya*: 1-4, *stictella*: 1, male, Welder Wildlife Refuge, Sinton, San Patricio Co., Texas, 30 June 1975 (U.S.N.M.); 2, male genitalia of same (slide A.B. 3828); 3, male genitalia of another male, same location, same date, (slide A.B. 3827); 4, same enlarged to show gnathos. 5, *ovaliger*, El Rancho Cima, Hays & Comal cos., Texas, 29 August 1975, slide A.B. 3826 enlarged to show gnathos.

species are definitely distinct. The habitus of *G. ovaliger* (Blanchard, 1975, Figs. 1-4) is quite different from that of *G. stictella* (this paper, Fig. 1 and Shaffer, 1968, Fig. 23). The differences between their male genitalia are not so obvious. Fig. 2 shows the genitalia of *G. stictella* prepared in the conventional manner. In Fig. 3 they are prepared in the manner favored by Shaffer (1968, page 3). Figs. 4 (*stictella*) and 5 (*ovaliger*) show the enlarged gnathos and the webs or ribs which support its apical process from beneath; this is where the most obvious difference between the two species is to be found. Dr. Shaffer, who had the opportunity to look at many more specimens than I had, gave me the following information: "These ribs are provided in *ovaliger* with a double row of teeth (two or three to six in each row). In *stictella* the number of teeth per row varies from zero to two. Counting is complicated by the fact that in both species the size of the teeth varies from large and well developed ones to tiny, barely discernible nubbins."

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PROTECTIVE BEHAVIOR IN *AMPLYPTERUS GANNASCUS* (SPHINGIDAE)

During August 1974, I spent about two weeks collecting Lepidoptera on the grounds of the Inter-American Institute of Agricultural Sciences, approximately 45 km SE of San Jose, Costa Rica (near the town of Turrialba). On two separate occasions I witnessed an interesting behavioral response in the sphingid *Amplifypterus gannascus* (Stoll), which was common in the area. A few *gannascus* would sometimes remain resting high up on the whitewashed walls of the Institute buildings until about 1000, having been attracted to these sites by the lights on the buildings the night before. In two cases it was possible to touch individuals by means of tossing a multi-segmented net about twelve feet long at them. The individuals responded to being touched by releasing their grip and sailing slowly to the ground in a slow spiralling descent, with their wings held rigidly in a swept-back V position. Once on the ground the moths remained passive in spite of being nudged, and only attempted to escape after being seized by hand. The appearance of this behavior was strikingly similar to the appearance of a dead leaf wafting to the ground from a tree, and would seem to be a behavioral adaptation to escape predators by imitating an unappetizing plant fragment.

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OENEIS ALBERTA (SATYRIDAE) IN MONTANA

Oeneis alberta Elwes has been taken to date in widely scattered colonies from Alberta, Manitoba and Saskatchewan (*alberta*), Colorado (*oslari* Skinner), Arizona (*daura* (Strecker) and New Mexico (*capulinensis* Brown). On 19 and 20 May 1976, a series of 21 males and 6 females of *alberta* was taken by the author from the high grasslands in the Little Snowy Mountains of central Montana, Fergus and Golden Valley counties. This is a new state record for the species in Montana. Habitat of the Golden Valley County colony is pictured in Fig. 1. Elevation is approximately 6500 feet. Specimens from the colony are shown in Fig. 2. The Montana colonies represent the nominate subspecies.

Additional colonies of *alberta* will probably be discovered in Montana as suitable habitat in areas east of the Continental Divide is explored at the proper time of year. Colonies should also be expected to occur in Wyoming and Utah, though none have been found thus far.

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Division of Forestry, 2705 Spurgin Road, Missoula, Montana 59801.



Fig. 1. Habitat of *Oeneis alberta* in the Little Snowy Mts., Golden Valley Co., Mont.

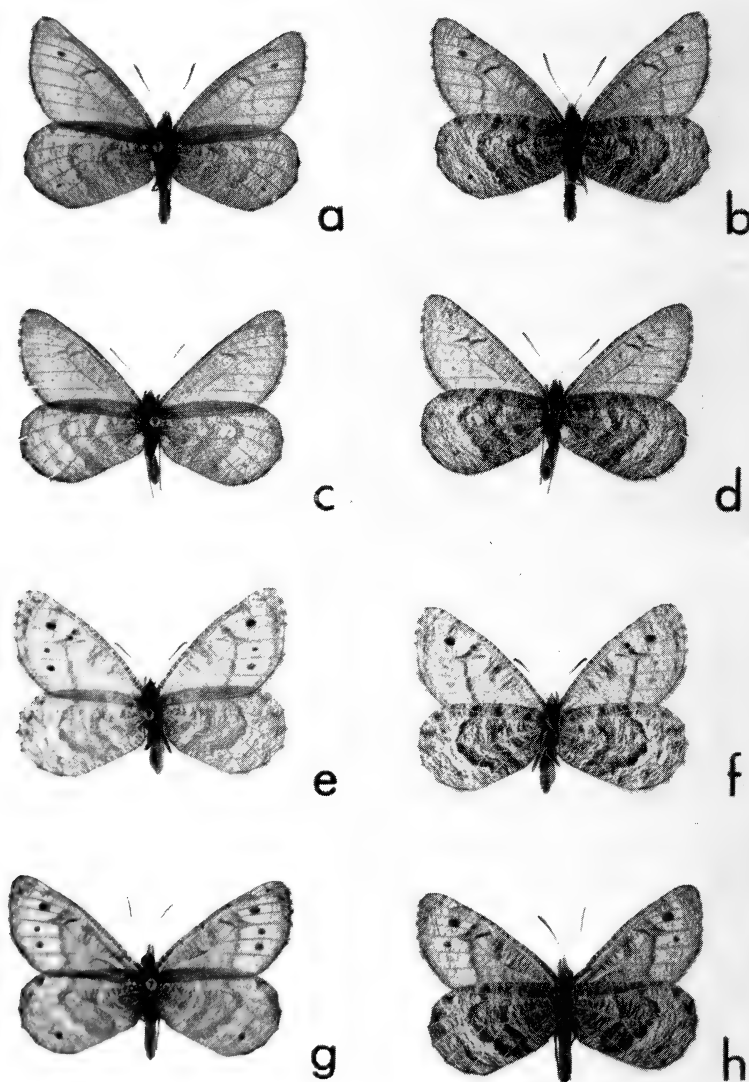


Fig. 2. *Oeneis alberta* from the Little Snowy Mts., Golden Valley Co., Mont. (a & c) males, dorsal; (b & d) same, ventral; (e & g) females, dorsal; (f & h) same, ventral. All photos natural size.

NEW OR INTERESTING LEPIDOPTERA RECORDS FROM WESTERN TEXAS

The Panhandle and South Plains areas of Texas have probably received less close attention from lepidopterists than other areas of the state because of the dearth of resident collectors and the greater number of interesting species in other parts of Texas. In view of the relative lack of information on Panhandle-Plains species, it seems worthwhile to publish certain significant records from my collection and the Texas Tech University collection at this time. I report herein one new Texas record (Pieridae) and additional records of species not usually associated with these areas of Texas.

PIERIDAE

Kricogonia lyside (Godart) has previously been reported from the Panhandle-Plains area only in October (Kendall and Freeman 1963, The Butterflies and Skippers of Texas: A Tentative List, Sinton, Texas, 6 p.). The Texas Tech University collection contains two males of this species from Lubbock, Texas (Lubbock Co.), both of which are in very good condition. One was collected on 12 July 1970 by D. W. Kiser, and the other on 24 September 1967 by U. Barber. In addition to these specimens, I collected one male and two females in fair condition at Palo Duro Canyon State Park, Randall Co., Texas, on 6 May 1977.

Phoebis agarithe maxima (Neumoegen). Although this species was not cited in Kendall and Freeman's checklist as having been recorded from the Panhandle-Plains region of Texas, the Texas Tech collection contains two males, in fair condition, from Lubbock, Texas (Lubbock Co.). One was collected on 7 July 1967 by "E J W," and the other on 16 September 1970 by P. M. Allen. I observed numerous males and females of *agarithe maxima* in Lubbock, Texas throughout September of 1976, and captured a single worn male on 19 September 1976.

Pieris napi (Linnaeus). The Texas Tech collection contains a single perfect male specimen of an undetermined subspecies collected on 17 August 1970, at Canyon, Texas (Randall Co.) by Walt Fournier, a former Tech graduate student. As far as can be determined, this record is a new one for the state of Texas.

LYCAENIDAE

Lycaeides melissa melissa (Edwards). I collected a single perfect male of this species on 31 August 1975 at the Buffalo Springs Lake Recreation Area (4 mi. E Lubbock, Lubbock Co., Texas). This record tends to support the contention by Rickard and Vernon (1975, *J. Lepid. Soc.*: 150) that this heretofore rarely reported species has probably just been overlooked in the past.

NYMPHALIDAE

Chlosyne janais (Drury). A single female of this common neotropical species was collected by me at my residence in Lubbock, Texas, on 11 June 1977. The specimen has badly torn hindwings but is in fair condition otherwise. This species has not previously been reported from the Panhandle-Plains region of Texas.

SATURNIIDAE

Hemileuca hera hera (Harris). Although Douglas C. Ferguson states that *hera* is "widespread in the West but not known from Texas" (1972, *Bombycoidea-Saturniidae* in part, p. 106, in R. B. Dominick, et al., *The Moths of America north of Mexico*, Fascicle 20.2B), the Texas Tech collection contains a single male in very good condition, collected on 16 September 1969 in Dickens, Texas (Dickens Co.) by M. Hughes.

Callosamia promethea (Drury). The Texas Tech collection contains one female,

in fair condition, collected on 2 September 1973 at Junction, Texas (Kimble Co.) by Tech graduate student Sandy M. Benbow. According to Ferguson (p. 235), *promethea* has not been cited previously as occurring west of Tyler, San Jacinto, and Montgomery counties in eastern Texas. Thus this record suggests a possible range extension of several hundred miles into the Edwards Plateau area. Texas Tech University students and faculty collect annually at a field campus in Junction, so it should be possible to determine if *promethea* is more than just a stray in the area.

ACKNOWLEDGMENTS

I wish to thank Roy O. Kendall of San Antonio, Texas, for reviewing this paper and confirming the identification of these specimens, and Dr. David E. Foster of the Texas Tech entomology faculty for allowing me to examine material in the Tech entomology collection.

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ERYNNIS BRIZO LACUSTRA AND HESPERIA COLUMBIA IN THE
SIERRA NEVADA

Burns (1964, U. C. Publ. Entomol. 37: 1-214) reports no records for *Erynnis brizo lacustra* Wright for the Sierra Nevada, and MacNeill (1964, U. C. Publ. Entomol. 35: 1-221) lists no records for *Hesperia columbia* Scudder from there except one female in the AMNH from "Sier. Nev." Both are indicator species of the coast range serpentine belts north of San Francisco. Until recently, serpentine outcrops have been little collected in the western foothills of the Sierra Nevada of east-central California. Table 1 (next page) lists the new distribution records there.

Sometimes the adults may fly a few miles from their serpentine areas to hilltop: e.g., both hilltop on Rocky Ridge, 1700-1900', N. of Monticello Dam, Yolo Co., a non-serpentine area composed of Upper Cretaceous marine rocks of the Venado Formation. The nearest serpentine occurs in the extensive Mesozoic ultrabasic intrusive rocks and the Franciscan Formation some 6 miles to the west. Similarly, Footman Ridge, Mariposa Co., is Paleozoic marine (also the area to the N & E), and to the south is Mesozoic granitic rocks, with no serpentine nearby. The nearest serpentine is found 5 mi. W. as Jurassic-Triassic metavolcanic rocks and 8 mi. SW near Mariposa as Mesozoic ultrabasic intrusive rocks. In the meadows, forests, and canyon immediately adjacent to Footman Ridge on the W & N, neither species has ever been collected.

On 15 May 1970, E. slope Walker Ridge along Brim Grade, c. 1800', SW of Leesville, Colusa-Lake Co. line, I noticed a female *lacustra* ovipositing on the terminal growth of a *Quercus durata* Jepson bush growing on serpentine soil along a roadbank, at 1125. Burns (1964) says "the skipper invariably occurs in direct association with *Q. durata*, a serpentine obligate" (see Whittaker et al., 1954, Ecology 35: 258-288). However, in some areas, it may also use *Quercus dumosa* Nutt. which hybridizes with *Q. durata* and grows in strictly non-serpentine soils (see Forde & Faris, 1962, Evolution 16: 338-347).

Heretofore, these skippers were considered more coastal in their California distribution.

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TABLE 1. Distribution Records of *Erynnis brizo lacustra* and *Hesperia columbia* from the Sierra Nevada of California.

Species	County	Locality	Elevation	Collection Date	No. & Sex	Collector	Comments
<i>E. b. lacustra</i>	Placer	6.5 rd. mi. NE Foresthill	C.4100'	26 May 1975 24 April 1976	— —	S. R. Sims S. R. Sims	commonly hill-topping on exposed serpentine ridge
<i>E. b. lacustra</i>	Placer	summit of limestone outcrop above Murderer's Bar, 1½ mi. E. of confluence of No. & Middle FK. American River, E. of Auburn	C.890'	19 March 1977	1 ♂	O. Shields	hilltopping in serpentine terrain
<i>E. b. lacustra</i>	El Dorado	No. FK. Consummes River on hilltop, vicinity of Mt. Aukum	C.2000'	1 May 1976	1 ♂	O. Shields	—
<i>E. b. lacustra</i>	El Dorado	Pine Hill summit, NE of Bass Lake	2050'	23 April 1972 14 April 1974	1 ♂ 3 ♂ ♂	O. Shields O. Shields	serpentine
<i>E. b. lacustra</i>	Mariposa	Footman Ridge summit, SE of Jerseydale	4600'	1 May 1974 23 May 1974 15 May 1976	2 ♂ ♂ 1 ♂ 1 ♂	O. Shields O. Shields O. Shields	—
<i>H. columbia</i>	Mariposa	Footman Ridge summit, SE of Jerseydale	4600'	23 May 1974 15 May 1976	2 ♂ ♂ 1 ♂	O. Shields O. Shields	—
<i>H. columbia</i>	Kern	hillside 3.2 mi. S. Bodfish on Bodfish-Caliente Rd.	3000'	31 March 1972	1 ♂	R. Wells	—

BOOK REVIEWS

THE BUTTERFLIES AND MOTHS OF HAMPSHIRE AND THE ISLE OF WIGHT (being an account of the whole of the Lepidoptera) by B. Goater. 1974. E. W. Classey, Ltd., Faringdon, Oxon, England. xiv + 439 pp. Price: £6.50, postpaid.

Perhaps nothing so authoritative as this book has been written on so small an area's fauna. The book is annotated with published records, manuscript notes and personal observations on all of the butterflies and moths of Hampshire and the Isle of Wight since the beginning of collecting there. Make no mistake, this book is an historical document, and as a record of what is (and was) in the County, and on the island, it is invaluable.

Goater has drawn records from many contemporary sources, and there are some prominent English entomological contributors to the list: such as D. W. Ffennell, John Heath, E. C. Pelham-Clinton, and the Baron C. G. M. de Worms, names well-known in English lepidopterology. This information provides a regional list unlike any we have seen and the coverage is complete through 1972.

Despite the lovely picture of *Argynnis paphia* on the cover, this is no "coffee table" book. It sticks strictly to business, and those looking for pretty pictures by which to identify British Lepidoptera should be forewarned to stay away from it. As a book of information (isn't that what we *really* need?), it is superb, and from it one can discover when, where and at what time any species of butterfly or moth has been captured in that area, and, if it has been reared, on what foodplant. I suspect that in this alone the book has fulfilled its purpose, and, additionally, it should stimulate the collector in the area to "fill in the blanks".

The nomenclature used is standard perhaps only to the British, since it is derived from the Kloet and Hincks *Checklist of British Insects, part 2, Lepidoptera*, 1972. In this treatment, the Hesperioidea and Papilionoidea directly follow the Pterophoroidea and precede the Bombycoidea. To a North American rhopalocelist this arrangement will seem strange, even incomprehensible, since there are few other classifications that follow this one. Most schemes place the butterflies and skippers above the Noctuidae, the "top" family in Goater's system. If you are interested in the butterflies, by the way, look on pp. 214-245. The sphingids may be found on pp. 307-312, and the saturniid (there is only one) on p. 248, while *Catocala* are on pp. 404-406. This gives a bit of a "road map" to the reader just trying the book for the first time (I confess to a great deal of initial confusion).

As stated before, don't buy this book on the basis of the pretty picture on its cover. Neither is this an identification manual. But if you are interested in a superb compendium of what is known about a limited fauna, by all means get the volume. It sets a fine standard, despite a few typographical errors not alluded to here (they happen to everyone!), for future lists on small faunas.

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BUTTERFLIES OF WEST MALAYSIA AND SINGAPORE by W. A. Fleming. 1975. E. W. Classey Ltd., Farington, Oxon, England. Vol. 1: vii-x+64 pp., pls. 1-54; vol. 2: vii-x+92 pp., pls. 55-90. Price: £19.50, postpaid.

This book, effective as it is, is something of an enigma. I find it impossible to rationalize making it in two volumes if the series is only to be sold as a whole, and not broken into separate volumes, if the buyer so desires. The text is identical in both volumes to page 15, so it is only in the plates and the parts following them that the two volumes differ. A little elementary arithmetic shows that if the volumes

were combined into a single one, there would be a very manageable and useful single book of four prefatory pages, 144 text pages and 90 plates. Surely this would have been a better plan. Maybe others will have the problem I did—I would refer to “the” book to identify a Malaysian butterfly, and I almost inevitably selected the wrong volume. The only excuse I can think of for publishing this work in two volumes is economic, and perhaps £19.50 for a single book would put off some buyers, but with the price of books what it is today, I doubt it.

But enough of the complaining. There is a multitude of information in this book, even though the style is such that it takes some acclimation. The nomenclature is up-to-date and applied to the right insects. Species in which the illustrations are not enough for identification are characterized in the text, and in those instances where genitalic dissection is necessary for final determination, the fact is noted, even though the genitalia are not figured. If Fleming had included some bibliographic citations to these problem areas, and to the many included foodplants records, the book would have been more authoritative, and the space these references would have added could not have been that much.

The illustrations, however, are where the books truly excel. All of the photographs of specimens illustrate the salient points well and facilitate the identification of the insects in question. All of the specimens used are not perfect; some are downright tatty, such as the illustrated female of S12, *Lethe europa malaya* Corbet on Plate 24, but these were the best specimens available in collections, and the photographs mercifully have not been “prettied up”. The color fidelity is very high, and at least most of the specimens are fresh, rather than century-old museum relics. Identification of even the difficult Malaysian lycaenids is facilitated by them, though of course it is not made simple—no book could achieve *that*!

I particularly appreciated the accurate citation of the authors of various taxa, even though these names were not bracketed where appropriate. At long last, both of the Felders are cited as the authors of names proposed in the “*Reise Novara*”, not just a blanket “Felder”. This latter practice seems to have dated from “Seitz” where only Cajetan Felder was given credit for the descriptions in the work, even though the authors themselves cited “*nobis*” on every new name, rather than the singular “*mihi*”.

On balance, this is an excellent book, the foregoing criticisms notwithstanding, and one that is remarkably free of typographical errors. The text portions are perhaps a bit too abbreviated, and authority is not given for many statements. I personally would have preferred a single volume about the size of Corbett and Pendlebury’s *The Butterflies of the Malay Peninsula*, but the present book accomplishes some things that the earlier authors could not: Fleming has made the identification of Malaysian butterflies considerably easier than before. No more can be asked of any author! If your interests lie in the butterflies of southeastern Asia, by all means buy this book.

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NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *duplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, $8\frac{1}{2} \times 11$ inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard, 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 p.

——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. *Adv. Genet.* 10: 165–216.

In the case of general notes, references should be given in the text as, Sheppard (1961, *Adv. Genet.* 10: 165–216) or (Sheppard 1961, *Sym. Roy. Entomol. Soc. London* 1: 23–30).

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JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



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Cover illustration: *Dasychira dorsipennata* larva, dorsal and lateral views. From Fascicle 22.2, "Lymantriidae," by Douglas C. Ferguson, in *Moths of America North of Mexico*. The drawing was done by E. R. Hodges, Scientific Illustrator, Department of Entomology, Smithsonian Institution. (Reproduced by permission of the author.)

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 32

1978

Number 2

Journal of the Lepidopterists' Society
32(2), 1978, 65-74

STUDIES ON THE INTERACTIONS OF *MORPHO PELEIDES* (MORPHIDAE) WITH LEGUMINOSAE

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ABSTRACT. The butterfly *Morpho peleides* Kollar is a widespread species throughout tropical America, exploiting several wild genera and species of Leguminosae as larval foodplants. Field studies show that this species feeds on a broad spectrum of wild legumes on a regional basis. This interaction was explored in the laboratory by rearing caterpillars on peanut plants and alfalfa, cultivated legumes. The life cycle is completed successfully on these artificial foodplants, but feeding on alfalfa taken from an expressway led to mass mortality of caterpillars. Apparently the alfalfa was contaminated from some environmental source. In the native habitats of this butterfly, the Leguminosae are both diverse and numerous locally. This suggests that the monophagous feeding habit provides sufficient ecological flexibility for exploiting different genera and species of the family. This is sufficient to maintain breeding populations of *M. peleides* in secondary habitats. Forest-dwelling species of *Morpho* are predicted to be experiencing different types of selection pressures favoring polyphagous feeding.

In the premontane tropical wet forest life zone (Tosi 1969) of north-eastern Costa Rica, a larval foodplant of the butterfly *Morpho peleides* Kollar (Lepidoptera: Morphidae) is the vine *Machaerium* aff. *floribundum* Benth. (Leguminosae). The vine and butterfly occur in stands of mixed primary and secondary tropical wet forest (Fig. 1). It is known that *M. peleides* utilizes several leguminous woody vines and trees as larval foodplants in Costa Rica (Young and Muyschondt 1973) and the species can be reared on commercially available peanut plants both in Costa Rica and Wisconsin (Young 1974). This present paper examines further the feeding habits of *M. peleides* larvae, using eggs obtained from a population in premontane tropical wet forest (rather than from montane forest, as in a previous study), and involves plants not studied previously (Young 1974). The results further support the assumption



Fig. 1. Above: mixed primary-secondary tropical wet forest habitat of the butterfly *Morpho peleides* at Finca El Tigre, near La Virgen, Heredia Province (Sarapiquí region), Costa Rica. At the spot shown here, *M. peleides* and *M. granadensis* are microsympatric. Below: *Machaerium* aff. *floribundum*, a forest leguminous vine which is a larval food plant of *M. peleides* (and probably *M. granadensis*) in the wild.

that larvae of *M. peleides* are monophagous feeders on many temperate and tropical genera of Leguminosae.

METHODS

A female of *M. peleides* was captured on bait of rotting bananas placed near the edge of a forest habitat (Fig. 1) on February 14, 1977 at "Finca El Tigre," a farm adjacent to "Finca La Tirimbina," a few km from La Virgen, Heredia Province (Sarapiquí region), Costa Rica (220 m elev.). She was placed in a clear plastic bag containing a fresh cutting of *M. aff. floribundum*, and within eight days had produced a total of 40 viable eggs. The female was then preserved, and the eggs were brought to Milwaukee, Wisconsin for rearing. The eggs began to hatch on February 25 in Costa Rica and by the time the morphos arrived in Wisconsin, they were all 1st instar. In Costa Rica these larvae were fed leaves of *Dioclea wilsoni* (Leguminosae) but they were switched to peanuts (*Arachis hypogea* L.—Leguminosae) upon arrival at the Milwaukee Public Museum. The larvae were kept on potted peanut plants placed in a covered glass tank in a laboratory. A growth light was kept over this rearing chamber. The rearing program in Wisconsin extended from March 3 through May 25, 1977 (the date of the late eclosion). Records were kept on body lengths and head capsule widths of all caterpillars. The sources of peanut plants used were (1) Olds Seeds from Madison, Wisconsin and (2) Crop Science Department of North Carolina State University (Raleigh). Near the end of the experiment (April 22), the foodplant was switched to alfalfa (*Medicago sativa* L.—Leguminosae); at this time most of the larvae were in the late 4th instar. The alfalfa plants used were obtained from a farm in Waukesha County, Wisconsin. Later (May 2) the remaining 5th instar larvae (several had pupated) were fed alfalfa collected from the side of an expressway in downtown Milwaukee. Like the peanuts, the alfalfa plants were potted, but this time soil brought in with the plants from the field was used. One 4th instar caterpillar was offered a seedling of *Erythrina crista-galli* L. (Leguminosae) from Brazil. Records were kept on larval survival throughout the study. The adults obtained were kept for further examination.

RESULTS

Both young and older larvae of *M. peleides* fed successfully on peanut and alfalfa leaves in the laboratory, followed by normal eclosion (Fig. 2). In addition, at least the 4th and 5th instar larvae will feed on *Erythrina*. Although some caterpillars feed intermittently throughout the day, the

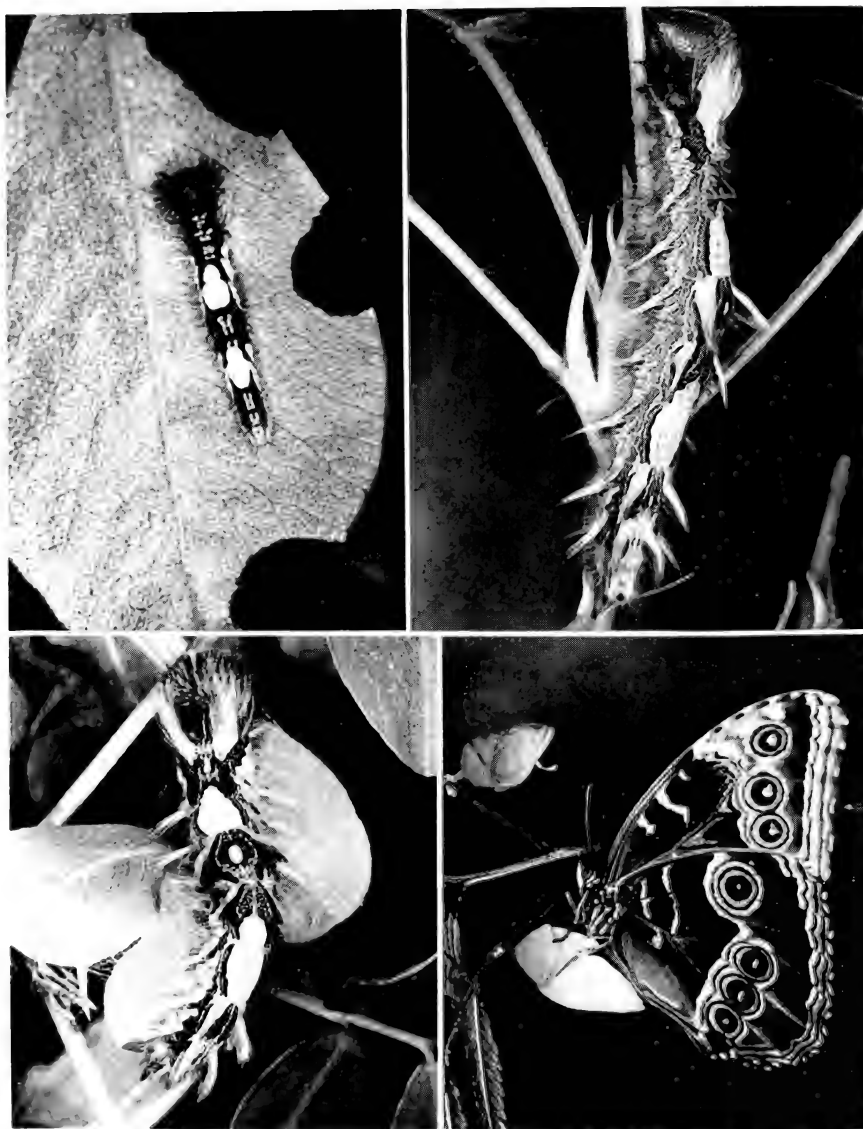


Fig. 2. Right column: second and fourth instar caterpillars of *M. pelecides* on peanut leaves at the Milwaukee Public Museum; note eaten areas of leaf in first illustration. Leaf column: fifth instar caterpillar on peanut plant and freshly-enclosed adult clinging to empty pupa case (at Milwaukee Public Museum).

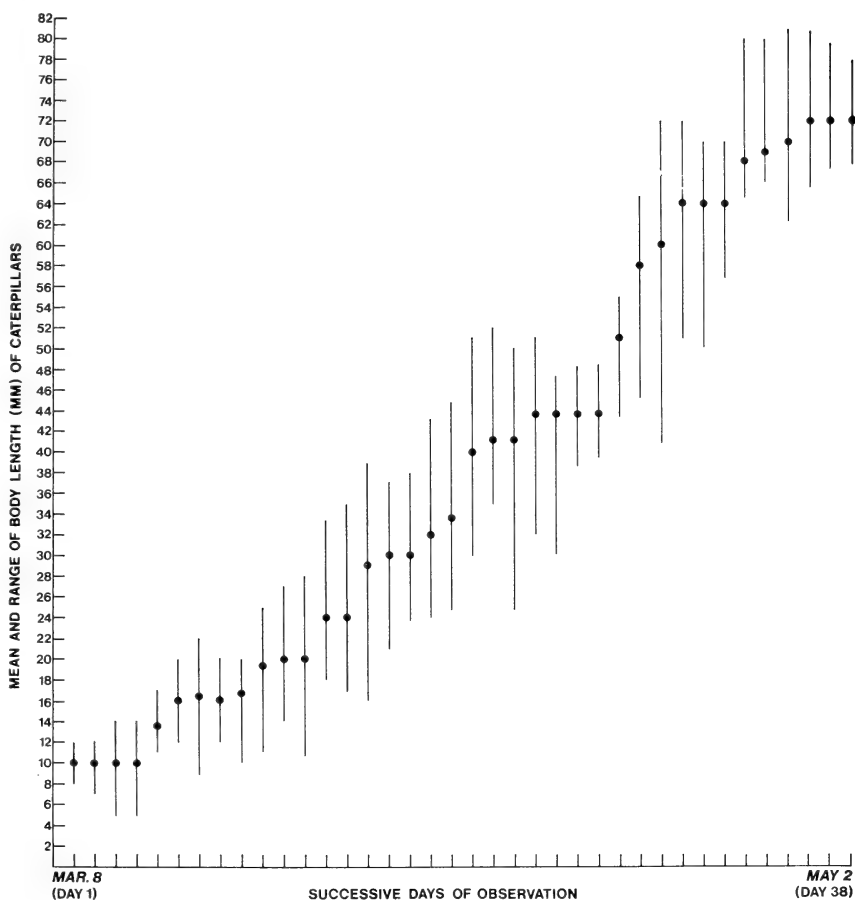


Fig. 3. Growth and size (body length) patterns for *Morpho* caterpillars reared in the laboratory. The vertical lines give the range in body lengths.

greatest amount of feeding occurred in the late afternoon and early morning (e.g., 16:00–19:30 hrs/C.S.T.). Fourth and 5th instar larvae rested on the rims of the pots containing the peanut plants, and they would crawl up the plants to feed. Younger ones rested on leaves and shoots.

Survival both on peanuts and on “farm alfalfa” was 100%. However, larvae fed “expressway alfalfa” showed considerable mortality: between May 4 and May 12, the number of healthy caterpillars dropped from 32 to 13. Very shortly after being fed the expressway alfalfa, many died. Death was preceded by a drastic contraction of body length, and spasmic

TABLE 1. Head capsule size statistics for caterpillars of the tropical butterfly *Morpho peleides*.

Instar	No. measured	Mean head capsule width ($\bar{x} \pm \text{S.D.}$)	Range of head capsule widths (mm)
1	17	1.50 ± 0.08	1.4-1.5
2	34	2.19 ± 0.09	2.0-2.3
3	33	3.47 ± 0.18	3.3-3.8
4	31	4.91 ± 0.11	4.7-5.1
5	11	6.09 ± 0.45	5.2-6.7

Note—data obtained from molted head capsules at the end of each instar [distorted (crushed) head capsules are not included in the calculations]. All head capsules were collected within 24 hours after each molt.

waves of movements lengthwise. Afflicted caterpillars fell from the plants and wriggled on the bottom of the cage before dying. When attempts were made to replace them on the foodplant, they again lost hold and fell off. Their feces had a reddish-orange component that was quickly absorbed on paper toweling. A few died as prepupae.

Initial signs of the affliction included a larva remaining stationary on the plant, with the anterior half of the body hanging off to one side. Such a state lasted a few days before the larva fell off the plant and died. As a result of this sudden and epidemic-like mortality, only those individuals that had already pupated by May 2 survived to emerge as adults. A total of 12 adults, all males, were obtained. Thus, the mortality was 100% among the 19 individuals that were still larvae on May 4.

Based on a sample of ten randomly chosen larvae, molting is not synchronous. The 5th instar is the longest, and despite changes in the foodplant type, development proceeds without major accelerations or decelerations in the daily pattern of growth (Fig. 3). With the exception of the 1st instar, there is considerable variation in the body length and the magnitude of this variation is about the same for the four instars (Table 1). Excluding a small bias introduced by unequal sample sizes, the range of variation in head capsule width is very low for all instars (Table 1). Body length and head capsule width are used here as estimates of larval size. The total development time of 91 days is broken down as follows: (1) egg = 11 days; (2) caterpillar = 65 days; (3) pupa = 15 days. The right forewing length for the adult male butterflies ranged from 55 to 65 mm ($N = 12$), but the exclusion of two individuals reduced this range to 61-65 mm.

DISCUSSION

The data are useful for discussing (1) feeding behavior of the caterpillars of *M. peleides*, and (2) apparent effects of environmental con-

tamination of a foodplant of an exotic butterfly. The latter was an unexpected outcome of the study.

Morpho accepts peanuts and other legumes, not used as foodplants in the wild, as discussed previously (Young 1974). But to these records I add alfalfa and *Erythrina* as acceptable foodplants of *M. peleides* caterpillars in the laboratory. *Erythrina* is native to the New World tropics (Bailey 1969), although it is not known if it is a natural foodplant of *Morpho*. Greenhouse cultures of this plant are usually infested with herbivorous insects, suggesting few effective defenses operative against such attacks. Alfalfa, a near relative of peanut, is commonly cultivated, and occurs as a weed species along roadsides; it is native to the Old World. As a weed species, alfalfa may possess few defenses against herbivores as energy allocation is likely to be directed toward high reproductive potential (Lewontin 1965). Thus, cultivars such as peanut and alfalfa, weeds such as alfalfa, and ornamentals, such as *Erythrina*, are examples of leguminous plant species with few defenses against herbivores, perhaps making them ideal to serve as food for *Morpho* larvae. It is not known if *Morpho* will oviposit on these plants in the laboratory.

I observed previously that caterpillars of *M. peleides* are primarily "dawn-dusk" feeders in the wild (Young 1972a), and this is also true for laboratory cultures experiencing the Wisconsin dawn-dusk cycle (Young 1974; pers. obs.). Apparently the larvae are programmed with a rhythmicity for peak periods of feeding activity in both tropical and temperate situations. In the wild, 4th and 5th instar caterpillars rest on the trunks of the foodplant where they blend in with the background (Young 1972a), and this behavior explains why they rested on the rims of the pots containing the peanut plants.

Using a larger sample size, Young (1974) estimated the total developmental time for *M. peleides* on peanuts to be about 105 days, or about 14 days longer than the estimate obtained in the present study. Body length of 5th instars in the previous study, was about 73 mm as compared to 70–71 mm in the present study. Several factors may be relevant here: (1) the eggs in the two studies came from different regions. Thus selection pressures could have been different in terms of effects on development time; (2) differences in the foodplant as related to time of the year, and other factors. The discrepancy in the development time is in the length of the larval stage; the egg and pupal stages are the same (Young 1974; pers. obs.). Thus, differences in the foodplant may be involved. Switching to alfalfa (not done in the previous study) might have accelerated development. To test this, eggs will have to be reared entirely on this plant in a future study. The transfer to alfalfa was done

in the fifth instar, the time of greatest food intake. In the previous study, older peanut plants were used, and it may well be that older plants have resistant properties more expressed than younger ones. There is some evidence that the defense systems of peanut plants change with age: in the present study I observed that *Morpho* larvae refuse to eat the first set of leaves of a peanut seedling, eating only shoot and leaf tissue above this point (S. Borkin and A. Young, pers. obs.).

The observed high level of mortality among 5th instar larvae on alfalfa plants taken from the downtown expressway may have been due to a contamination of these particular plants by an industrial or automobile residue. An exotic insect such as *Morpho*, when exposed to a contaminated foodplant, may be expected to encounter such mortality. Since only male adults were reared I presume that all the females died as 5th instar larvae, since *M. peleides* has a sex ratio of unity (Young 1972b, 1973; Young and Muyschondt 1973). Female larval development generally takes longer than that of males. The observed inability of afflicted larvae to grasp the foodplant and feed was very likely due to the contaminant affecting the nervous system. It is not likely that a strain difference affecting feeding ability by morphos exists between the expressway alfalfa and farm alfalfa, since larvae did eat the former and until the time of obvious signs of illness, their feeding behavior appeared normal.

The data indicate that feeding flexibility of *M. peleides* caterpillars is considerable in the sense that it allows this monophagous tropical herbivore to exploit a broad range of genera and species locally. Foodplant records for *M. peleides* from Costa Rica and El Salvador indicate that many different wild Leguminosae are used, and allied South American species exhibit similar behavioral flexibility (Otero 1971; pers. comm.). Secondary forest habitats in the wetter regions of Central America locally support a wealth of leguminous vine, shrub, and tree species, many of which are used by *M. peleides*. It is therefore not surprising that caterpillars will feed successfully on allied legumes not used as natural foodplants, including cultivated forms such as peanuts and alfalfa. On a per unit area basis, secondary habitats in the tropics support large patches of *Mucuna*, *Dioclea*, *Machaerium*, *Inga*, etc. and many patches may occur locally. Thus, in terms of larval foodplants, the environment is very certain or predictable creating selection pressures favoring ecological specialization such as monophagy. As foodplant patches increase in number and size in an area, monophagy is considered an optimal feeding strategy for a herbivore (Levins and MacArthur 1969).

Some species of *Morpho* that live in the canopy of primary tropical forest deposit eggs on different families of trees and woody vines (Otero,

pers. comm.) and these species may be polyphagous. Miller (1968) lists several *Morpho* foodplant families, although the degree to which each species oviposits on more than one family has not been determined. Polyphagy in *Morpho* is adaptive in habitats where individuals of each foodplant species are greatly dispersed over large areas, making it energetically difficult to exploit a single family of foodplants. In forest habitats where each foodplant species is greatly dispersed over large areas, the environment is less certain in terms of a female butterfly locating successfully an individual of that particular plant. As more plants are added to the local foodplant niche, the environment becomes more certain; the incorporation of additional local foodplants implies the evolution of polyphagy, since member genera and species of individual plant families in tropical forests are greatly dispersed over large areas. Thus, although *M. peleides* and its near allies such as *M. achilles* may exhibit considerable feeding flexibility within the Leguminosae, they are monophagous species; polyphagous species of *Morpho* are expected to occur in primary forests. These include such likely candidates as *M. amathonte*, *theseus*, *grandensis*, and *cypris* in the Central American rain forests.

ACKNOWLEDGMENTS

This research would not have been possible without the financial support of the Friends of the Museum (of the Milwaukee Public Museum) and James R. Neidhoefer. Susan Borkin and Joan Jass (Milwaukee Public Museum) conducted the rearing studies and assisted with taking measurements. Dr. J. Robert Hunter allowed me to work at Finca El Tigre and Dr. Ridgway Satterthwaite of the Associated Colleges of the Midwest provided logistical assistance in various ways. Luis D. Gomez of the Museo Nacional de Costa Rica provided a field vehicle. Janice Mahlberg of the Milwaukee Public Museum provided photographic assistance. The assistance of Dr. Martyn Dibben and Neil Luebke with growing peanut plants at the museum is greatly appreciated. I also thank Joe Sugg, head of the North Carolina Peanut Council and Dr. Harry Cobel (Crop Science, North Carolina State University) for arranging peanut plants to be sent to me when the museum supply was defoliated. I thank Cheryl Castelli for typing the manuscript. To all of these people I am very grateful.

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NOTES AND DESCRIPTIONS OF EUPTYCHIINI (LEPIDOPTERA: SATYRIDAE) FROM THE MEXICAN REGION

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ABSTRACT. Several species of Euptychiini (Lepidoptera: Satyridae) are discussed and/or described. Described as new: *Taygetis mermeria griseomarginata* (Guerrero, Mexico), *Splendeuptychia kendalli* (Tamaulipas, Mexico), and *Cyllopsis wellingi* (Cayo dist., British Honduras). The previously unknown female of *Cyllopsis dospassosi* L. Miller is described and figured.

Some years ago Mr. Roy O. Kendall of San Antonio, Texas sent me a strange euptychiine satyrid from northern Mexico for identification. It was apparent that the specimen was a representative of a new species in the genus *Splendeuptychia* Forster (1964), a group hitherto known from no further north than Panama. Since the Panamanian species, *S. salvini* (Butler), was unrepresented in the Allyn Museum collection, I compared the Mexican insect with the colored figures of *salvini* given by Butler (1866) and by Godman and Salvin (1880 [1879-1901]). Many discrepancies between the two insects became obvious, and a hurried call to Mr. Gordon B. Small, Jr. of Balboa, Canal Zone resulted in his sending two males of *S. salvini* that confirmed the superficial differences between it and the Mexican butterfly as well as genitalic ones.

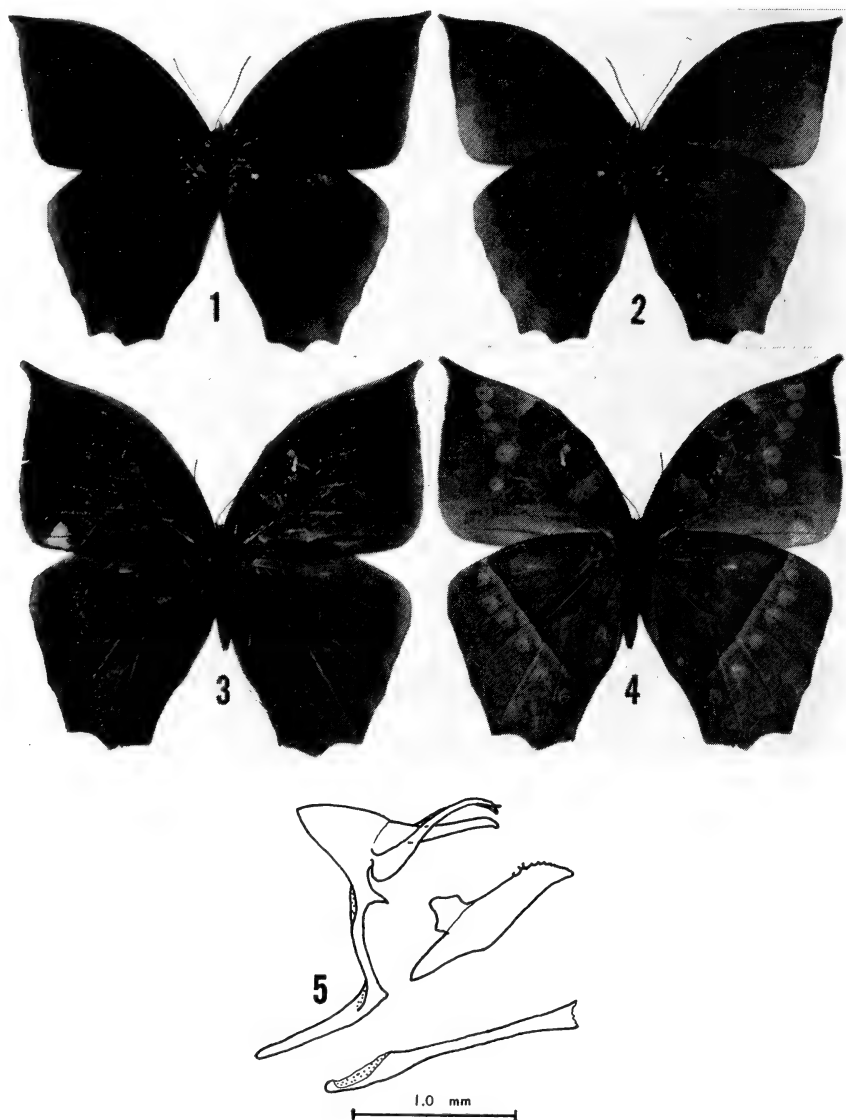
Once Mr. Kendall and his wife had managed to rear the Mexican *Splendeuptychia* they needed a name on which to base the paper that follows. Accordingly, I am taking this opportunity to describe the new *Splendeuptychia* and some other euptychiines from the Mexican region. Additional data are given on species that have come to my attention since the publication of portions of my revision of the tribe. Some of the new species described herein are members of genera not covered in the revision yet, but it is felt that publication of these parts may be so far in the future that other workers could benefit by having the names proposed at this time.

***Taygetis mermeria griseomarginata* L. Miller, new subspecies**

Figs. 1-5

Male: Head, thorax and abdomen clothed with dark brown dorsal and tan to reddish-tan ventral hairs. Palpi reddish-tan, somewhat darker laterad. Antennae dark brown dorsad, reddish-brown checkered with tan ventrad. Legs clothed with brown hairs laterad, reddish-tan ones on inner portions of segments.

Wings with acutely falcate forewing apices as in *T. mermeria excavata* Butler (1868). Upper surfaces of wings dark, rich brown, unmarked except for broad (4-8 mm) grayish overscaling along margins of all wings and more narrowly and



Figs. 1-5. *Taygetis mermeria griseomarginata*, n. ssp. 1-2, Holotype ♂ upper (1) and under (2) surfaces; MEXICO: GUERRERO: Acahuizotla (Allyn Mus. photos 101476-7/8); LFW (length of forewing) 47.0 mm. 3-4, Paratype ♀ upper (3) and under (4) surfaces; MEXICO: COLIMA: Comala (Allyn Mus. photos 101476-9/10); LFW 55.2 mm. 5, ♂ genitalia of Holotype; slide M-2732 (Lee D. Miller).

less prominently along forewing costa. Under surfaces of all wings mottled in various shades of brown, reddish-brown grayish-tan or ochreous (highly variable individually) with forewing mesial bands poorly developed and only the extradiscal bands of the hindwings well developed (usually delimited by some gray-green scaling distad of the dark brown bands themselves); ocelli of both wings varying from very well developed to obsolescent. Fringes of all wings gray above, tan to reddish-brown below.

♂ genitalia similar to those of other Mexican specimens (*excavata*) with somewhat stubbier valvae than those of South American representatives.

Length of forewing of Holotype ♂ 47.0 mm, those of the 21 ♂ Paratypes ranging from 44.6 to 53.3 mm, averaging 50.35 mm.

Female: Similar in appearance to the ♂, differing chiefly in the paler coloration both dorsally and ventrally and by the presence of a poorly defined transcellular band of the hindwings beneath that is not shown by the ♂.

Lengths of the forewings of the seven ♀ Paratypes range from 54.1 to 58.0 mm, averaging 55.95 mm.

Described from 29 specimens, 22 males and seven females, from the western slope of the Sierra Madre Occidental, Mexico.

Holotype ♂: MEXICO: GUERRERO: Acahuizotla, ix.1957 (T. Escalante); ♂ genitalia slide M-2732 (Lee D. Miller).

Paratypes: all MEXICO. GUERRERO: same locality as Holotype, 1♂ viii.1957, 5♂ ix.1957, 1♂ x.1957, 1♀ viii.1958, 1♀ iii.1958 (all T. Escalante); Tierra Colorado, 12♂ 4♀ viii-ix.1971 (all A. Diaz Frances). NAYARIT: vic. Compostela, 1♂ 1.x.1932 (A. B. Klots). COLIMA: Colima, 1♂ 11.i.1968; Comala, 1♂ 31.x.1967, 1♀ 14.i.1968 (all R. Wind).

Disposition of type-series: Holotype ♂, 17♂ and seven ♀ Paratypes in Allyn Museum of Entomology; single ♂ Paratypes will be placed in the American Museum of Natural History, the National Museum of Natural History, Carnegie Museum and the British Museum (Natural History).

The name of this subspecies refers to the broadly gray dusted margins of both wings on the upper surfaces. This situation is only hinted at in specimens of *T. m. excavata* in which the maximum development of this marginal gray scaling is about 1-1.5 mm on the forewing and virtually absent on the hindwing. In the present subspecies this gray marginal scaling is most prominent on the hindwing, but the forewing scaling is more extensive than on any *excavata* specimen.

This gray-margined subspecies is apparently restricted to the western slopes of the Sierra Madre Occidental from at least Nayarit to Guerrero. While I have not seen material from all of the states in this area, I feel confident that *griseomarginata* will be found in Jalisco, Michoacan and possibly southernmost Sinaloa. A single specimen in the Allyn Museum collection from Chiapas (Tuxtla Gutierrez, 13.viii.1961, *leg.* "M. S.") that was part of the Jae collection is referable to *griseomarginata*, but since all material from Oaxaca and Chiapas that I have seen has been referable to only *excavata*, I have excluded this Chiapas specimen from the type-series. It may have been mislabelled, or it may represent a genetic "throwback", but it certainly is not typical of Chiapas-Oaxaca before me. All of the specimens I have seen from the Nayarit to Guerrero

range have been referable to *griseomarginata*, and the presence of a single specimen from outside this range should not be taken as "proof" that the subspecies does not exist.

Splendeuptychia salvini (Butler), 1866

Figs. 6-8

Euptychia salvini Butler, 1866: 498 (type locality: Lion Hill, [Canal Zone], "Panama").

Forster (1964: 128 ff.) erected the genus *Splendeuptychia* for 23 Neotropical species, most of which are restricted to South America. The species included in the present genus are among the loveliest of the Euptychiini, and their pattern is unmistakable. Only *S. salvini* has thus far been reported from Central America, and it is restricted to the Canal Zone and adjacent Panama, possibly as far south as the Darién. *S. salvini* seems to be a rare butterfly, at least in collections. I suspect that this appearance of rarity is real, since the insect is one of the more spectacular Satyridae and should not be overlooked by even a casual collector.

Two males were obtained from Gordon B. Small, Jr. for examination and comparison with the Mexican species described below. The differences are cited under the new species, but it suffices to say here that the two are not conspecific.

Splendeuptychia kendalli L. Miller, new species

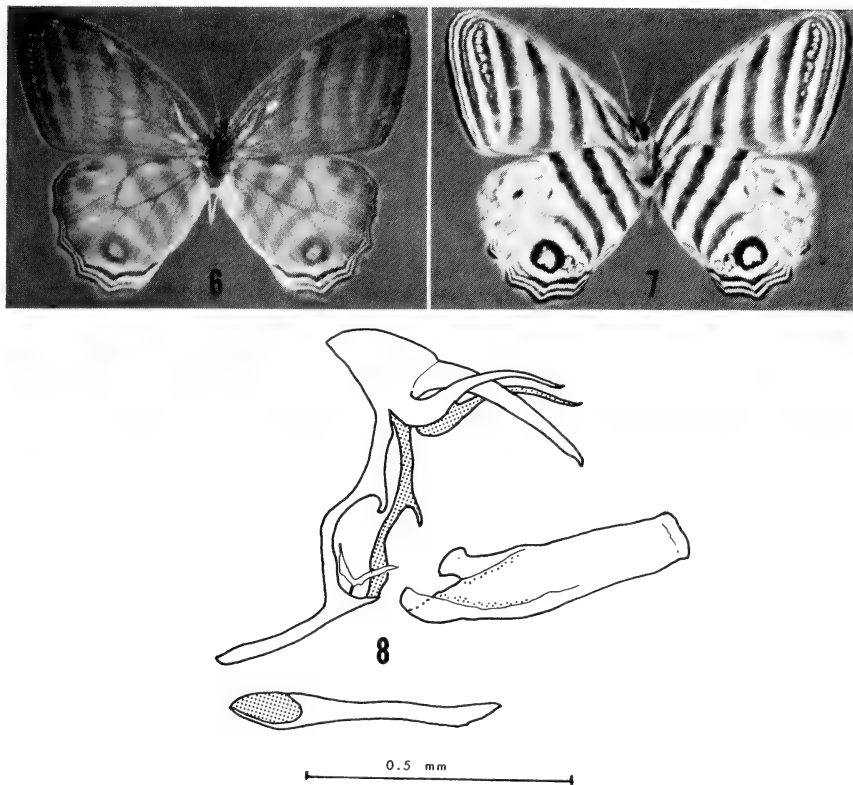
Figs. 9-13

Male: Head, thorax and abdomen clothed with gray-brown dorsal and ochreous-tan ventral hairs. Palpi pale gray laterad and dark gray ventrad and dorsad. Antennae brown dorsad, reddish-brown ventrad; tip of club slightly darker. Legs clothed with gray hairs, but those of tarsi tan.

Wings above dull brown with three dark brown marginal lines separated by tan; otherwise unmarked, but the markings of the under surface showing through vaguely on this surface. Forewings below gray-brown in proximal half, tan in distal half; two thickened rust-brown lines, one across cell, the other just outside cell dividing the gray-brown from the tan ground color; three almost straight dark brown marginal lines; between the marginal lines and the distal band is a row of black-edged silver spots from M_1 - M_2 to Cu_1 -2A, the whole spotband surrounded by a thin brown ring. Hindwings below with gray-brown proximal and tan distal ground color; thickened rust-brown bands of forewing continued on hindwing; three thin, dark brown marginal lines following the slightly crenulate wing outline; a mesial to submarginal yellow patch from Rs - M_1 to Cu_1 -2A encompassing silvered spots in the interspaces, those in Rs - M_1 , M_1 - M_2 and Cu_1 - Cu_2 with well defined black irides; a subsidiary black line between the marginal lines and the yellow patch from Cu_1 to the tornus; along M_2 and Cu_1 are two black submarginal patches. Fringes pale gray above, tan below.

♂ genitalia as figured, differing from those of *S. salvini* (Fig. 8) in many respects, especially the shorter gnathos arms and the simpler valvae.

Length of forewing of Holotype ♂ 17.8 mm, those of the 37 ♂ Paratypes ranging from 16.7 to 18.8 mm, averaging 17.67 mm.



Figs. 6-8. *Splendeptychia salvini* (Butler). 6-7, ♂ upper (6) and under (7) surfaces; PANAMA: PANAMA: Bayano, nr. Piña (Allyn Mus. photos 010677-11/12); LFW 15.9 mm; G. B. Small, Jr. collection. 8, ♂ genitalia of same specimen; slide M-3418 (Lee D. Miller).

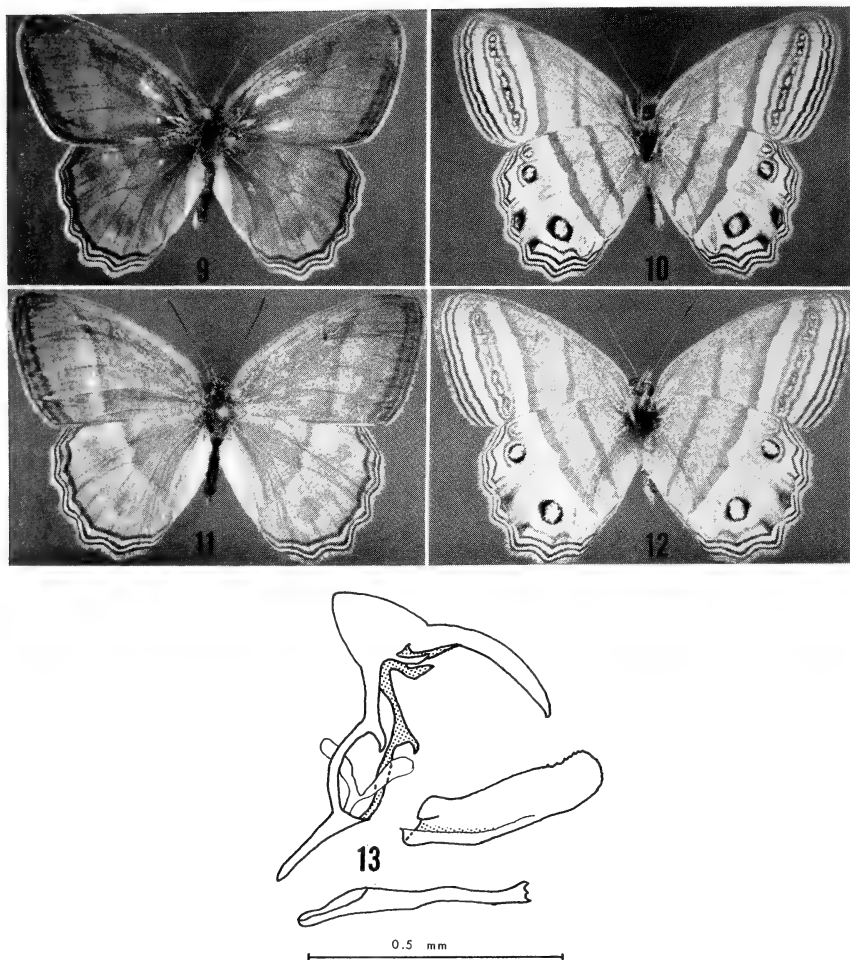
Female: Very similar to the ♂, differing chiefly in size, slightly paler coloration and the more extensive yellow patches of the hindwing under surface.

Lengths of forewings of the 36 ♀ Paratypes range from 17.3 to 21.0 mm, averaging 18.84 mm.

Described from 74 specimens, 38 males and 36 females, from the Mexican states of Tamaulipas and San Luis Potosí.

Holotype ♂: MEXICO: TAMAULIPAS: Gonzalez Ranch, nr. Los Kikos, *ex ovum* on *Bambusa aculeata*, emerged 9.i.1975 (R. O. and C. A. Kendall); chromosome specimen no. 3A-32-M; ♂ genitalia slide M-3651 (Lee D. Miller).

Paratypes: all MEXICO. TAMAULIPAS: same locality as Holotype, 2♂ 1♀ xii.1972, 1♀ vii.1973, 19♂ 13♀ x.1973, 2♂ 2♀ i.1974, 1♂ ii.1974, 3♂ 4♀ xi.1974, 2♂ 1♀ xii.1974, 1♂ 7♀ i.1975, reared from *Bambusa aculeata* (all collected or reared by R. O. and C. A. Kendall or W. W. McGuire). SAN LUIS POTOSÍ: Ciudad Valles, 2♀ vii.1970, 1♂ vii.1972, 3♂ 3♀ vii.1973 (all collected by H. A. Freeman); El Naranjo, 3♂ 1♀ ii.1976 (all collected by R. O. Kendall); Tama-zunchale, 1♀ vii.1951 (T. Escalante).



Figs. 9-13. *Splendeuptychia kendalli*, n. sp. 9-10, Holotype ♂ upper (9) and under (10) surfaces; MEXICO: TAMAULIPAS: Gonzalez Ranch, nr. Los Kikos (Allyn Mus. photos 010677-16/17); LFW 17.8 mm. 11-12, Paratype ♀ upper (11) and under (12) surfaces; same locality as Holotype (Allyn Mus. photos 010677-14/15); LFW 19.6 mm. 13, ♂ genitalia of Holotype; slide M-3651 (Lee D. Miller).

Disposition of type-series: Holotype ♂, 10 ♂ and 10 ♀ Paratypes in the collection of the Allyn Museum of Entomology; nine ♂ and 10 ♀ Paratypes returned to R. O. Kendall; 19 ♂ and 15 ♀ Paratypes returned to W. W. McGuire. These series will be divided later among other museum collections.

I take great pleasure in naming this distinctive Mexican satyrid for

Mr. Roy O. Kendall who reared the Holotype and several other examples in the type-series. His work on the life histories of various Mexican, as well as Texan, butterflies has been of the greatest value to lepidopterology and promises even more future benefits to the science.

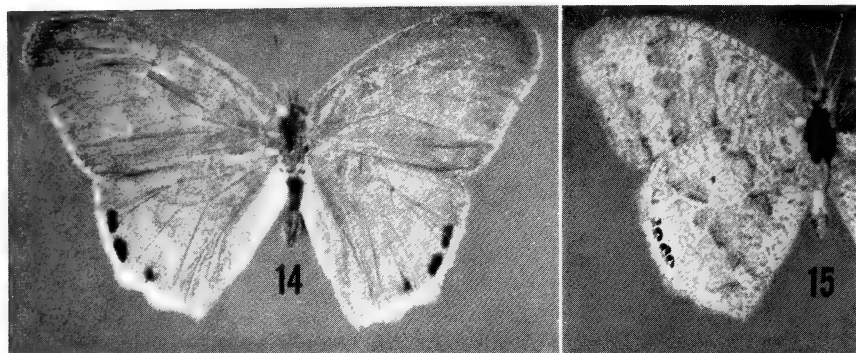
The Tamazunchale specimen came from the Escalante collection and bore a cryptic determination label in an unknown hand identifying the specimen as *S. salvini*. I had previously discounted *salvini* as the name for the Mexican butterfly, and the receipt of true *salvini* confirmed my previous analysis.

The genitalia are somewhat aberrant for members of *Splendeptychia* (Forster, 1964: figs. 161-164), especially in regard to the aborted gnathos.

In addition to the genitalic dissimilarities between *kendalli* and *salvini*, the former may be distinguished by the following superficial characters: 1) the ground color of *kendalli* is browner, both dorsad and ventrad; 2) the marginal lines on the upper surface are better developed in *kendalli*; 3) the ventral forewing of *salvini* bears four dark bands proximad of the silver spotband, whereas in *kendalli* the basal of these is missing altogether and the distal band is merely a thin line forming part of the ring around the silvered spots; 4) the ventral hindwing of *kendalli* also lacks the basalmost band that is prominent in *salvini*; 5) the yellow patch of the ventral hindwing is more extensive in *kendalli*, whereas in *salvini* this patch is poorly developed to absent posteriad of vein Cu_1 ; and 6) the silver spotband of the ventral forewing which extends posteriad as far as 2A in *kendalli* reaches no further posteriad than Cu_2 in *salvini*.

This species is apparently restricted to the mesic environments found in a few places in the eastern foothills of the Sierra Madre Oriental. Thus far the butterfly has been found in a very few localities from Tamazunchale north to Tamaulipas where colonies of *B. aculeata* grow. What we know about the bionomics of *S. kendalli* is given in a following paper (Kendall, 1978). Obviously, the insect is multivoltine.

Members of *Splendeptychia* are almost uniformly rare. I suspect this is a real occurrence, since they are much more attractive than are most Euptychiini. Perhaps the relative abundance of *S. kendalli* and its association with *Bambusa* will make possible the discovery of greater numbers of other species of *Splendeptychia*. The association of this genus with bamboo is further confirmed by S. S. Nicolay who brought me several specimens of an as yet undetermined *Splendeptychia* that he took in a bamboo thicket in eastern Ecuador.



Figs. 14-15. *Cyllopsis dospassosi* L. Miller, ♀ upper (14) and under (15) surfaces; MEXICO: SAN LUIS POTOSÍ: El Salto Falls (Allyn Mus. photos 010677-2/3); LFW 17.7 mm; R. O. Kendall collection.

Cyllopsis dospassosi L. Miller, 1969

Figs. 14-15

Cyllopsis dospassosi L. Miller, 1969 ("1968"): 53; 1974: 84-86 (type locality: 52 mi. E Ciudad Victoria, Tamaulipas, Mexico).

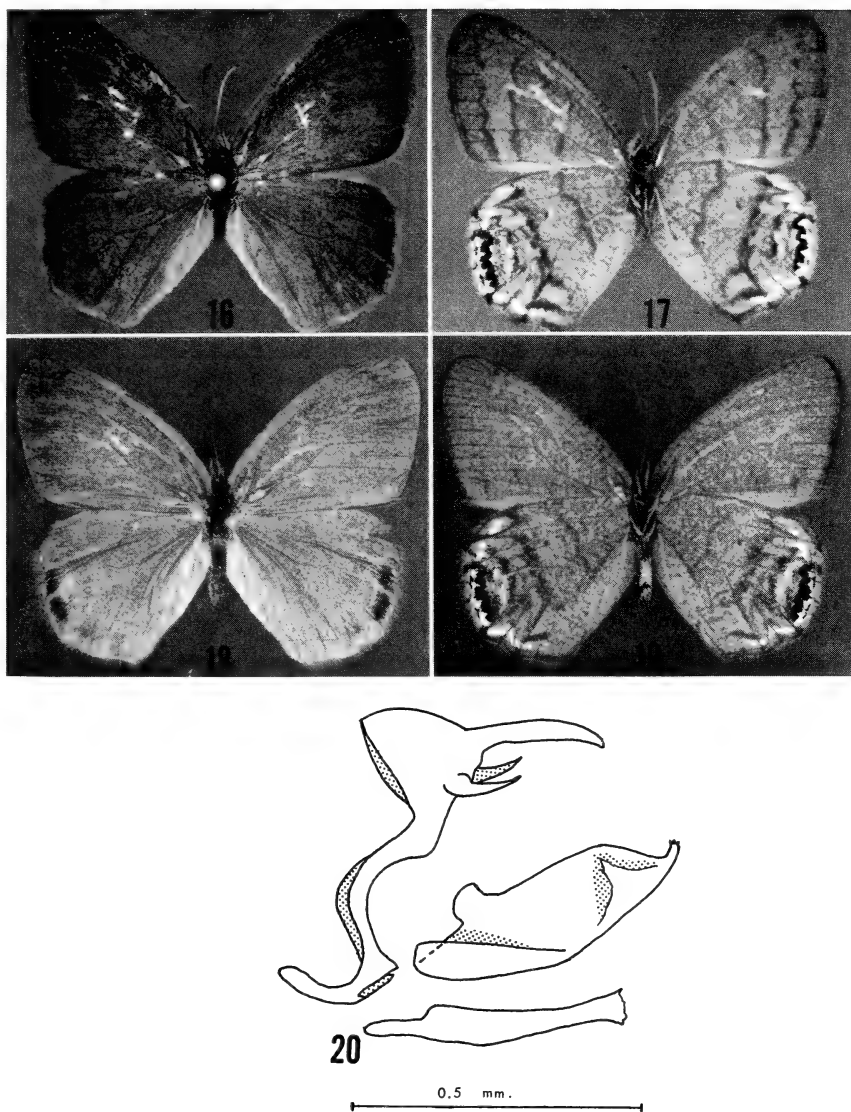
The type of this species remained unique until Mr. and Mrs. Kendall collected one at El Salto Falls, San Luis Potosí on 16.i.1975. This specimen is the second known example of *dospassosi* and, fortunately, is the first female. It is quite comparable to the male, but the ground color of the upper side is slightly darker, and that of the under surface is somewhat less olivaceous. Nevertheless, the maculation of the under surface is comparable to that of the male with the addition of an ochreous outer element to the extradiscal band of the hindwing. The "gray patch" enclosing the ocelli of the ventral hindwing is obscure, as in the male. The length of the forewing is 17.7 mm. I have not done a genitalic dissection of this specimen since the female genitalia are not diagnostic in *Cyllopsis* (L. Miller, 1974: 4).

The Kendalls' specimen of this species (which is in their collection) extends the known range of *C. dospassosi* from the Sierra de Tamaulipas to the dry eastern flanks of the Sierra Madre Oriental, presumably of Tamaulipas, as well as San Luis Potosí. The range of *C. dospassosi* may be much wider than previously thought, and its rarity in collections may be attributable to the usual lack of collecting of the smaller Euptychiini.

Cyllopsis wellingi L. Miller, new species

Figs. 16-20

Male: Superficially like *C. nayarit* (R. Chermock), but differing in the following particulars: somewhat larger, approaching size of *C. pephredo* (Godman);



Figs. 16-20. *Cyllopsis wellingi*, n. sp. 16-17, Holotype ♂ upper (16) and under (17) surfaces; BRITISH HONDURAS (BELIZE): Cayo District: Pine Ridge, Thousand Foot Falls (Allyn Mus. photos 021777-1/2); LFW 17.3 mm. 18-19, Paratype ♀ upper (18) and under (19) surfaces; same locality as Holotype; (Allyn Mus. photos 021677-1/2); LFW 18.5 mm. 20, ♂ genitalia of Holotype; slide M-3667 (Lee D. Miller).

under surface bands on both wings redder than in either species; transcellular bands of both wings below less well developed than in *nayarit*; ochreous markings of hindwing below much more extensive than in *nayarit* (these are only hinted at in *pephredo*); and ocelli not edged inwardly with ochreous in gray patch area, as in *nayarit*.

♂ genitalia as figured, not at all resembling those of *pephredo*. The genitalia do bear some resemblance to those of *C. pseudopephredo* (R. Chermock) (L. Miller, 1974: fig. 141), a species that is otherwise quite distinct from *wellingi* and other members of the *pephredo* subgroup in its lack of an androconial patch. The valvae of the present species are somewhat broader than those of *pseudopephredo*, but the characteristic inwardly directed teeth (which usually appear as dorsally diverted ones) are very similar.

Length of forewing of Holotype ♂ 17.3 mm, those of the 11 ♂ Paratypes ranging from 17.0 to 18.2 mm, averaging 17.48 mm.

Female: Differs from the ♀ of *C. nayarit* in much the same manner as does the ♂, with the additional characteristic of a reddish flush on the upper surface of some specimens that is not shown in other members of the *pephredo* subgroup.

Lengths of forewings of the eight ♀ Paratypes range from 17.9 to 19.1 mm, averaging 18.45 mm.

Described from 20 specimens, 12 males and eight females, from British Honduras (Belize).

Holotype ♂: BRITISH HONDURAS: Cayo District: Pine Ridge, Thousand Foot Falls, 650 m, 2.ix.1976 (E. C. Welling M); ♂ genitalia slide M-3667 (Lee D. Miller).

Paratypes: all same locality as Holotype, 2-3.ix.1976 (E. C. Welling M.), 11 ♂ 8 ♀ (males all determined genitally).

Disposition of type-series: Entire type-series placed in Allyn Museum of Entomology, but the series may be subdivided later.

It is with great pleasure that I name this little satyrid for Sr. Eduardo C. Welling M. of Mérida, Yucatán, Mexico. He has consistently been available to collect specimens of Euptychiini for me, and has often placed undescribed and unexpected species at our disposal for systematic work.

This species is something of a puzzle. One male of thirteen in front of me was a specimen of *C. pephredo*, but all of the others were the new insect, as demonstrated by genitalic dissections. I have no idea why the single *pephredo* was intermingled with *wellingi* at the type locality of the latter, and this single specimen represents the first record of *pephredo* from British Honduras. These two species now bring the total number of *Cyllopsis* from that country to three (*C. gemma freemani* [Stallings and Turner] also occurs there).

ACKNOWLEDGMENTS

I am most grateful to Messrs. Roy O. Kendall, E. C. Welling M., Gordon B. Small, Jr. and Alberto Diaz F. and Drs. W. W. McGuire and Tarsicio Escalante for providing the material on which this is based. Mr. A. C. Allyn took the photographs used to illustrate the paper. Mr. Allyn and my wife and colleague, Jacqueline, read and suggested upon the paper. To all of these individuals I owe a great debt of gratitude.

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LARVAL FOODPLANT, LIFE HISTORY NOTES AND TEMPORAL
DISTRIBUTION FOR *SPLENDEUPTYCHIA KENDALLI*
(SATYRIDAE) FROM MEXICO¹

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ABSTRACT. Larval foodplant, *Bambusa aculeata*, Gramineae, rearing notes, ecologic and temporal distribution at its northern distributional limit, are recorded for *Splendeuptychia kendalli* Miller.

Field-collected adults of the satyrid, *Splendeuptychia kendalli* Miller, were found at 2 locations: 1) along the Rio Sabinas at Rancho Pico de Oro near Ciudad Mante, Tamaulipas, and 2) along the Rio Salto at El Naranjo, San Luis Potosí. This species is closely associated with its larval foodplant, *Bambusa aculeata* (Ruprecht) Hitchcock, Gramineae. It is doubtless that this insect will be found at other locations along water courses where its larval foodplant grows. Adults were taken in January, February, July, October, November, and December over a 4-year period. The areas were not visited during the other months. It is therefore unknown whether this multivoltine species is continuous brooded; it may have a reproductive diapause.

Rearing. At Rancho Pico de Oro, 21 December 1972, I observed a ♀ deposit a single egg on a juvenile leaf of *B. aculeata*. The ♀ was not captured, but the egg was recovered and preserved.

Again at this location on 22 January 1974, two females were collected and kept for egg production. Between 23 January and 2 February, 51 eggs were deposited in confinement on *B. aculeata*. Most of the eggs were deposited by 1 female which died 2 February. The other female was killed at this time, and both adults were preserved in alcohol together with 6 eggs. The remaining eggs hatched between 28 January and 7 February. Larval losses were rather high resulting from an inadequate supply of fresh food. Attempts to keep the plants fresh in a refrigerator were only moderately successful. Earlier, several specimens of the foodplant were transplanted to the Los Arcos Courts gardens at Ciudad Mante, our field headquarters, but they did not survive. In an attempt to circumvent a 60-mile trip every few days for larval food, the larvae were offered bermuda grass, *Cynodon dactylon* (L.) Pers. The

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larvae ate the bermuda grass, and it was thought a laboratory solution had been found for rearing this species. However, the larvae soon began to die. The bermuda grass may have been toxic to the larvae, but the lack of proper nourishment in the grass was suspect. On 6 April 1974 all remaining larvae (24) were preserved.

Once again a ♀ collected 23 November 1974 from this location deposited 27 eggs between 24 and 29 November and died 3 December 1974. These eggs hatched between 28 November–11 December, and a maximum effort was made to rear them. Numerous trips were made to the collection site for fresh bamboo. Even so, there were several larval casualties attributed to rapid desiccation of the cut bamboo. Eleven larvae pupated between 27 December 1974 and 12 January 1975. Adults emerged (2 ♂, 7 ♀) between 7 and 23 January 1975. Two larvae and 2 pupae (one deformed) were preserved.

Field-Collected Adults. In addition to the above, other field collections include: Rancho Pico de Oro, 21 December 1972 (2 ♂, 1 ♀), 9 January 1974 (3 ♀), 22 January 1974 (1 ♂), 22 February 1974 (1 ♂), 23 November 1974 (4 ♂, 1 ♀), 4 December 1974 (1 ♂), 6 December 1974 (3 ♀), and 8 January 1975 (1 ♂), all *leg.* Roy O. and C. A. Kendall. At the same location, 27 December 1972 (1 ♂), 18 July 1973 (1 ♀), 20 July 1973 (2 ♀), 22 October 1973 (17 ♂, 8 ♀), 25 October 1973 (3 ♂, 2 ♀) all *leg.* W. W. McGuire. At El Naranjo, 13 February 1976 (1 ♂), 14 February 1976 (2 ♂), and 29 February 1976 (1 ♂) all *leg.* Roy O. and C. A. Kendall.

ACKNOWLEDGMENTS

Mrs. Kendall and I wish to thank Sr. and Sra. Carlos Gonzales for permission to conduct field research at their rancho, and for their warm hospitality. To Sr. and Sra. Fernando Reyes Bugarin and their family we are most grateful for the comfortable field headquarters provided and for the use of their botanical gardens in our research.

NOTES ON THE LIFE CYCLE AND NATURAL HISTORY OF *VANESSA ANNABELLA* (NYMPHALIDAE)

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ABSTRACT. Observations on the life history of *Vanessa annabella* (Field) show the early stages to be quite variable: the eggs in rib structure, and the later larval stages in color pattern and behavior. Immature and adult behavioral characteristics are similar to those of other *Vanessa*. *V. annabella* is usually present throughout the year in coastal southern California.

Vanessa annabella (Field), the West Coast Lady, is a common and familiar butterfly in western North America. Because it can usually be found throughout the year in coastal southern California, opportunities to study its life history are almost always present. However, there are few published records available and none has included photographs of the complete life cycle. Of published reports, Dyar (1889) gave one of the more complete written accounts; Huguenin (1921) made some general observations on the life cycle and natural history; and Coolidge (1925) described the egg in detail and listed the larval foodplants. More recently Emmel & Emmel (1973) illustrated paintings of a light form of the last instar larva and the pupa and gave brief descriptive notes.

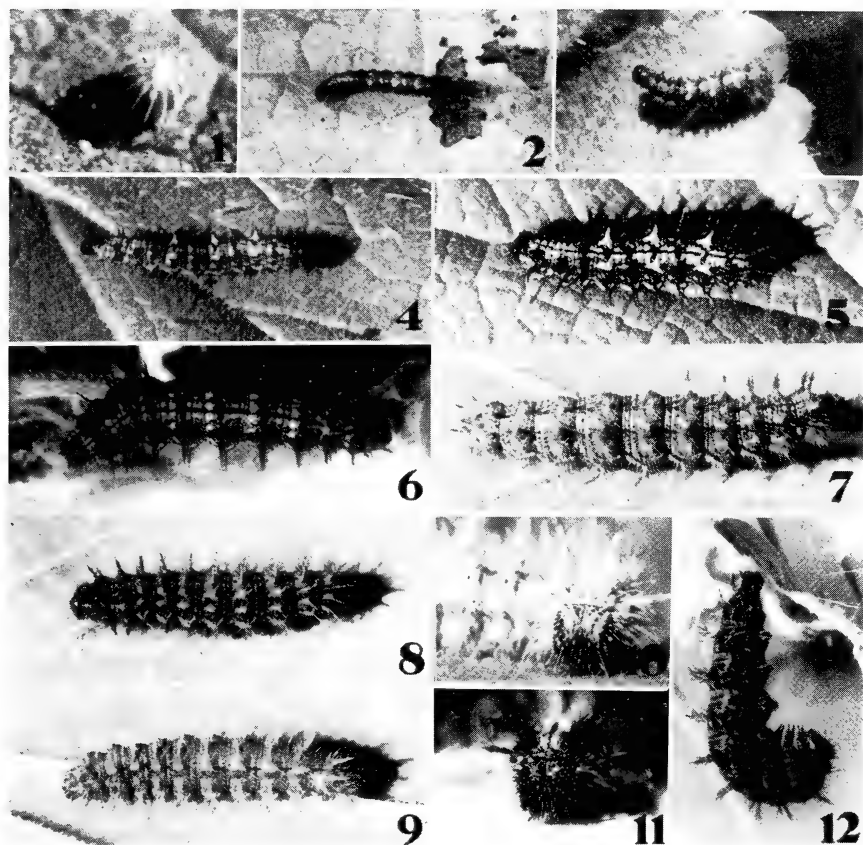
Specimens used for the present descriptions of the life cycle stages were collected as freshly laid ova by following an ovipositing female at the type locality in Ventura, California (Dimock, 1972). The leaves on which these eggs were laid were placed in plastic containers 11 cm square by 4 cm deep. Humidity was maintained by dampened tissue paper placed on the container bottom. The containers were kept indoors in a room temperature which varied from 17 to 25°C. Photographs and measurements were made of each stage. Other specimens were reared upon cut stalks of nettle placed in water so that leaf shelter construction and other activities could be observed. Afternoon sunshine provided direct and ambient light.

Full descriptions of the adults are given by Field (1971); thus, the following adult descriptions are limited to those characteristics which help distinguish *V. annabella* from related North American species.

Life Cycle Stages

Egg (Fig. 1). Barrel-shaped, light green, with 10 to 14 transparent vertical ribs. Measurements (Coolidge, 1925): 0.72 mm tall, 0.52 mm wide, tapering to 0.30 mm at base and 0.26 mm at top. Duration 4 days.

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Figs. 1-12. *Vanessa annabella* (Field): (1) egg, ca. 0.5 mm wide; (2) first instar larva, 3 mm; (3) second instar larva, ca. 4 mm; (4) third instar larva, ca. 9 mm; (5) fourth instar larva, ca. 13 mm; fifth instar larvae, all ca. 30 mm: (6) dark morph, black and yellow, (7) intermediate morph, orange and gray, (8) rusty orange morph, (9) light morph, gray; (10) head, fifth instar, light tan morph; (11) head, fifth instar, dark morph; (12) prepupa.

First instar larva (Fig. 2). Head shiny black, setae and thoracic legs black. Ground color grayish brown after feeding for 2 days. When mature, body with vague brownish mottling. Segments A-2, A-4, and A-6 with a pair of light yellow spots between subdorsal and supralateral setae. Grows to 3 mm in 5 days.

Second instar larva (Fig. 3). Head shiny black. Ground color mottled dark brown. Short branched spines black except for middorsal spines on A-4 and A-6 and subdorsal spines on A-2, A-4, and A-6, which are yellow. A narrow pair of vague yellow lines divided by a narrow middorsal line of dark ground color running from about T-1 to A-8. Grows to 4.5 mm in ca. 3 days.

Third instar larva (Fig. 4). Head shiny black with black setae arising from black chalazae. Ground color usually black, but may begin to lighten as in lighter morphs. Spines black except for subdorsal spines on A-2, A-4, A-6, and usually



Fig. 13. *Vanessa annabella* (Field): fifth instar larval nest on *Urtica holosericea* Nutt.

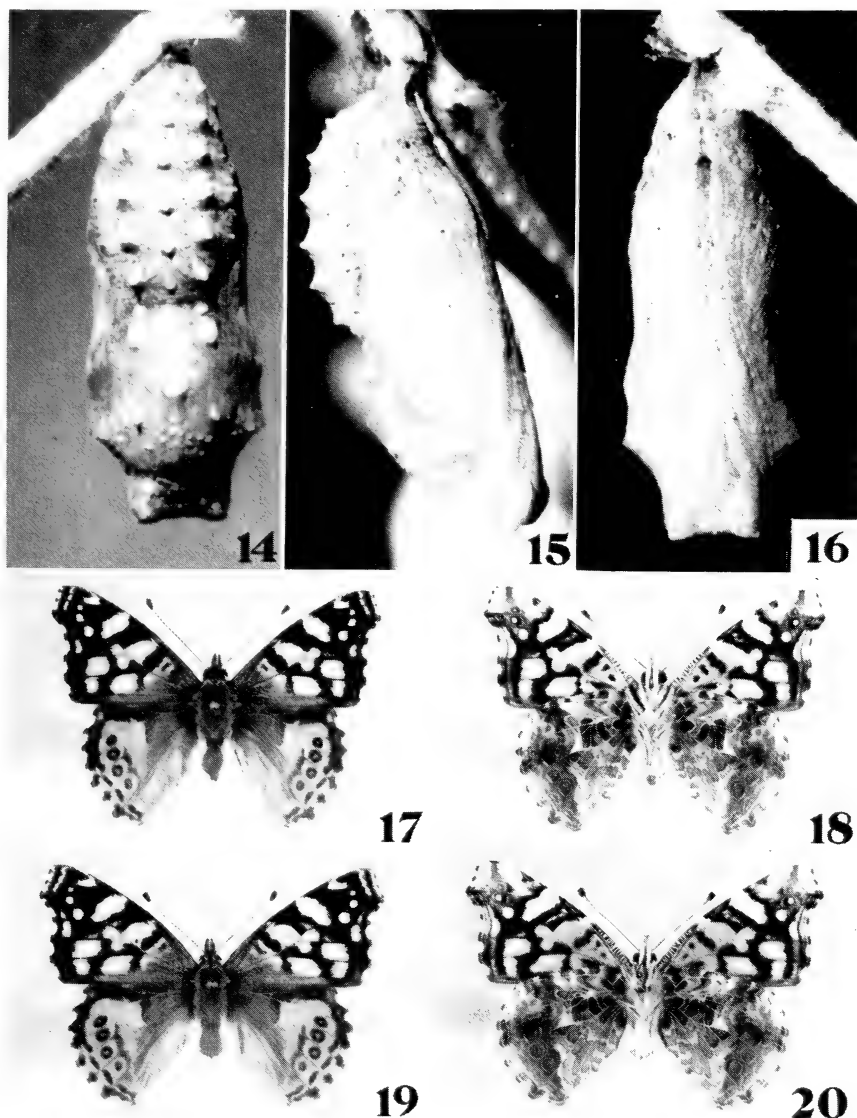
middorsal spines on A-4 and A-6, which are yellow with black tips and yellow bases confluent with dorsal double yellow lines. These paired lines, variable in expression, separated by a middorsal line of ground color, are interrupted by ground color at bases of non-yellow spines. Grows to ca. 9 mm in ca. 3 days.

Fourth instar larva (Fig. 5). Head black with bronze highlights. Head capsule width 1.5 mm. Ground color and markings nearly as variable as in fifth instar (see following description). Grows to ca. 14 mm in ca. 3 days.

Fifth instar larva (Figs. 6-9). Head blackish or brownish black (Fig. 11) with bronze highlights, or less often with vertical whitish tan stripes in light morphs (Fig. 10). Capsule width 2 mm. Extremely variable in ground color and markings. Ground color varies from black to greenish white or grayish white, including various browns and tans. Light markings present in fourth instar here vary from dark rusty reds and oranges to yellow or various browns and tans. Extent of markings and lateral line varies independently of color; these tend to disappear altogether in morphs of whitish ground color. Lateral line may be absent in any morph. Rusty orange spots may appear between subdorsal and supralateral spine bases, varying in extent from absence to confluence with other pattern elements. Spines branched, variable from black in dark morphs to whitish in light morphs, or dark anteriorly and light posteriorly in intermediate morphs. Arrangement of spines: middorsal row on segments A-1 to A-8, subdorsal rows on T-2 to A-8, supralateral rows on T-2 to A-10, and lateral rows on A-1 to A-8. Body shape thickest at midabdominal segments. Grows to ca. 25-30 mm in ca. 5 days.

Prepupa (Fig. 12). Light markings darken somewhat. Larva becomes slightly shorter and thicker. Duration 1 day.

Pupa (Figs. 14-16). Head without projections. Mesothorax with a raised middorsal point and a pair of subdorsal points. Metathorax with two large sub-



Figs. 14–20. *Vanessa annabella* (Field): (14) pupa, dorsal view, 19 mm; (15) pupa, lateral view; (16) pupa, ventral view; (17) adult male, dorsal view, 47-mm expanse; (18) adult male, ventral view; (19) adult female, dorsal view, 49-mm expanse; (20) adult female, ventral view.

dorsal white spots, raised anteriorly. Abdomen with two small subdorsal white spots on A-1 bordering those on metathorax. A-2 to A-7 each with one very small middorsal point and a pair of more prominent subdorsal points. Color variable from overall tan to mottled dark browns, sometimes with a greenish golden cast.

A spiracular line, darker brown than ground color, is variable in expression. Measurements (average of five specimens): length 19 mm; width 7 mm; depths: thorax 6.25 mm, saddle 5.25 mm, abdomen 7.25 mm. Duration 8–11 days.

Adults (Figs. 17–20). Sexual dimorphism subtle, females having a more rounded hindwing than males, especially at M_3 , Cu_1 , and Cu_2 . Color pattern same in both sexes: tawny orange with black markings, white subapical forewing spots, and blue pupilled hindwing ocelli. On upperside, forewing cell crossed completely by a black bar. Forewing costal bar, between cell end and apex, orange. Forewing apex pointed, not rounded, at M_1 , with marginal tawny spot in interspace Rs. Hindwing with four blue pupilled submarginal ocelli in interspaces M_1 , M_2 , M_3 , and Cu_1 , and often a small solid black ocellus in interspace Rs. Hindwing undersides mottled principally in various buffs, tans, browns, and grays, with a whitish triangle in interspace M_2 at cell end. Expanse averages between 40 and 48 mm, females often larger than males.

Total developmental time for this species is ca. 30 to 36 days.

Natural History

Vanessa annabella uses a variety of foodplants in the families Urticaceae and Malvaceae. Native foodplants most frequently used in southern California are *Urtica holosericea* Nutt. (Urticaceae), *Sida* species, *Sidalcea malvaeflora* (DC.) Gray, and *Sphaeralcea ambigua* Gray (Malvaceae). Introduced plants include *Malva* species, especially *M. parviflora* L., and *Althaea rosea* (L.) Cav. (Malvaceae). John F. Emmel, M.D. (pers. comm.) also reports the use of *Urtica urens* L. (Urticaceae).

The eggs are laid singly, usually on the uppersides of the leaves. On nettles (*Urtica*) the eggs are often attached to the sides of the stinging spines.

The hatching larva eats away the top and adjacent walls of the egg and crawls to a suitable place on the leaf uppersurface to construct a shelter. This consists of fine silk webbing tied across a leaf midrib, petiole, or small wrinkle on the leaf margin. The young larva lives under this webbing as it feeds on the leaf and places its frass into the webbing, creating a protective camouflage. In the second instar the larva may enlarge the old nest or construct a new one nearby. When the larva is at the growing tip of a nettle stalk, the nest may incorporate two or more of the tiny new leaves. By the third instar the larva is capable of folding a larger area of the leaf or constructing a deeper nest at the petiole. In the fourth instar the entire leaf may be folded together (on *Urtica*) or closed about the top edges (on *Malva*). Frass is allowed to fall out of the nest but often accumulates in piles in the nest bottom. The fifth instar larval nest is usually larger and may incorporate neighboring leaves and stems (Fig. 13). Sometimes leaves of nearby plants which are not foodplants are also tied into the nest even though they are

not eaten. On plants with small leaves, such as young *Malva*, the larva may tie together many leaves before a nest enclosure is completed. On *Urtica holosericea*, when a single leaf is used, larvae of *V. annabella* usually construct nests on the uppersides of the leaves, either by folding over one edge and securing it to the leaf surface or by tying both edges together to form an enclosure. The petiole or nearby midribs may or may not be partially cut to cause the leaf to hang vertically. Less frequently, the larvae will fold the leaf edges underneath so that the undersurface forms the nest interior.

Pupation sites are on either the foodplant or nearby objects. When the foodplant is used, a leaf chamber is constructed with firm webbing and the larva suspends itself from the chamber ceiling. Larvae in other locations may secure together any nearby objects to approximate an enclosure or may simply pupate in exposed places, such as from twigs or branches. Pupae often react to disturbances by wiggling laterally.

Emerging adults hang from the pupal shell or adjacent perch to expand their wings. A reddish brown meconium is ejected and the adult is ready for flight in an hour.

Adults of *V. annabella* may be encountered in any life zone from sea level to alpine areas where open sunny places are preferred. Both sexes visit flowers. In the afternoon males tend to congregate on hilltops or other exposed places such as forest openings, glades, meadows, and streamside slopes, especially when patches of dry, bare earth are available for sunning. Many man-made situations are particularly favorable: windbreaks of trees, orchard rows, trails, firebreaks, garden paths, and paved sidewalks and driveways. At these locations, when not occupied in sunning, males will chase after each other and the other vanessid butterflies *Vanessa atalanta rubria* (Fruhstorfer), *V. cardui* (L.), and *V. virginiensis* (Drury), along with unrelated butterflies which congregate in the same places. They often bravely chase larger insects and birds and in general will investigate anything that flies through their established area, including falling leaves and objects thrown overhead. These activities ultimately bring the males into contact and subsequent courtship and mating with females, but between these encounters the males spend a great deal of time and energy simply chasing each other. From observations made on hilltops in the vicinity of Ventura, California, during November 1976 when all four *Vanessa* were present, it was noted that any one species will chase the same or any other species, and two or more individuals may join in the chase. The butterflies may chase each other to a height of ca. 20 m or more before breaking chase and quickly gliding down to land once again on the ground with backs to the

sun and wings spread. The butterflies' wings frequently come into contact during these encounters, but without damaging effects, and the resulting noise can be heard nearby.

Females, although not congregating in the manner of the males, are likely to be found anywhere, feeding, seeking foodplants, or ovipositing, including hilltop localities when the foodplants or nectar sources occur there also.

The flight of *V. annabella* is composed of glides with the wings held horizontally, interrupted frequently by several fluttering beats. Chasing is mostly vigorous fluttering, and the return dives are composed of gliding and braking.

Diapause was not investigated, but if it does occur in this species it is almost certainly during the adult stage, as it is in the other vanessid-nymphaliniid butterflies. If adults of *V. annabella* are unable to survive prolonged or severe frosts, the species probably reinvades the greater part of its northern and eastern range from the milder southwestern areas where breeding is continuous throughout the year.

Vanessa annabella is easily attracted to suburban gardens by planting *Althaea rosea* (Hollyhock) or encouraging *Malva parviflora* (Cheese-weed) to become established. It is an easy butterfly to raise in captivity, even under poor conditions. Larvae collected in the wild on one foodplant (for example, *Urtica holosericea*) can be switched to other foodplants (*Malva*, *Althaea*) when the former is less easily obtained. The larvae are very often parasitized by tachinid flies, which emerge from the mature butterfly larvae or pupae as mature maggots.

DISCUSSION

Coolidge (1925) noted that the egg ribs of *V. annabella* varied in number from 11 to 13, with 11 the most common number. My observations confirm this, but eggs with 10 and 14 ribs were found during the present study. This is in partial disagreement with Field (1971), who stated that the genus *Cynthia* (in which *annabella* was placed) had from 14 to 19 egg ribs, and Clench (in Howe, 1975), who gave 14 or 15 as the number of egg ribs in the subgenus *Cynthia*.

The larvae of *V. annabella* are extremely variable, as are the larvae of *V. atalanta rubria* and *V. cardui*, and this variability not only makes a written description difficult but compounds the task of providing reliable characteristics with which the three species can be separated. In general, the descriptions given for the larvae in this article can be compared with those for *V. a. rubria* and *V. cardui* in subsequent articles. However, fifth instar larvae of *V. annabella* can always be distinguished

by their smaller head capsule width of 2 mm; in *V. a. rubria* and *V. cardui* the fifth instar larval head capsule is nearly 3 mm. Once *V. annabella* is identified, *V. a. rubria* is distinguished by the numerous white cephalic chalazae, which in *V. cardui* are black.

From observations made on *V. annabella* larvae collected in various locations and larvae reared under controlled conditions, it was noted that the variations in ground color were at least partly due to environmental conditions. The light, grayish-white morphs were more frequently encountered on plants exposed to full sunshine, whereas the darker morphs were found mostly on plants in secluded, shaded areas. Darker morphs also resulted when larvae were reared under crowded conditions.

Because *Malva* species are especially successful in disturbed areas and are abundantly available throughout the year as foodplants, *V. annabella* has probably become much more common since the introduction of these weeds from Europe. This is the situation in the coastal southern California lowlands, where a favorable climate prevails and *V. annabella* can be found in every month of the year.

In his revision of the *Vanessa* butterflies, Field (1971) resurrected the genus *Cynthia* for the *carye*, *cardui*, and *virginiensis* species groups. Clench (in Howe, 1975) reunites all the species in *Vanessa*, treating *Cynthia* as a subgenus. Emmel & Emmel (1973) used the cases of hybridization between *V. a. rubria* and *Cynthia annabella* to demonstrate the "close genetic relationship and probable generic identity" of the two species. With no disrespect to the fine work of Field, I favor a treatment similar to that of Clench, with reservations on the precise placement of *annabella*. There are 10 known cases of hybridization between *V. a. rubria* and *V. annabella*: one specimen reported by Edwards (1877), one by Grinnell (1918), one by Gunder (1930), three by Dimock (1973), one by Emmel & Emmel (1973), one specimen collected by Kirby in the collection of the Natural History Museum of Los Angeles County, and two specimens raised by Henne and Ingham in the Peabody Museum collection. Mr. William D. Field (pers. comm.) discovered upon dissection the partially crippled specimen designated as "Hybrid #3" in Dimock (1973) to be a female, not a male as erroneously reported. In my opinion these occurrences support, at least, the arrangement of Clench and the generic identity suggested by Emmel & Emmel. Biologically, the examples of hybridization may also demonstrate the presence of an as yet incomplete reproductive isolatory mechanism caused by a recent invasion of *V. annabella* from South America or a recent invasion of *V. a. rubria* from Eurasia, or invasions by both species.

ACKNOWLEDGMENTS

I wish to thank my father, M. W. Dimock, for printing the photographs which accompany this article; Mr. Julian P. Donahue of the Natural History Museum of Los Angeles County for access to the Museum collection; Mr. Christopher Henne of Pearblossom, California, for an account of his hybrids; Mr. William D. Field of the Smithsonian Institution, Washington, D.C., for information on the hybrids; Dr. John F. Emmel, Hemet, California, for reviewing the manuscript; and Mr. Alberto Mui-shondt of El Salvador for recommendations on photographic techniques and whose format for life history observations of El Salvador butterflies is the one I followed for this article.

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A NEW SPECIES OF *HEMILEUCA* FROM THE SOUTHWESTERN UNITED STATES (SATURNIIDAE)

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ABSTRACT. *Hemileuca griffini* Tuskes which occurs in southern Utah and northern Arizona was collected for the first time in 1974. The adult moth is a black and white day flying saturniid which is active during September and October. The larval hostplant is black brush, *Coleogyne ramosissima*. This species has a unique taxonomic position in that both the adult and larva exhibit morphological characters which are intermediate to the *Pseudohazis* and *Hemileuca* groups, thus, a continuum of characters exists between these two previously separated genera.

The genus *Hemileuca* consists of 23 described species, 16 of which have partial or complete distributional patterns north of Mexico. The moths within this genus are large to moderate in size, and exhibit a great deal of hostplant and habitat diversity. Adults are characterized by having the labial palpi fused to each other forming a small unsegmented bilobed structure; also, the male has bipectinate antennae. Members of *Coloradia*, the genus most closely related to *Hemileuca*, have labial palpi which are separate, and males have antennae which are quadripectinate.

The last *Hemileuca* described as a distinct species was *chinatiensis* (Tinkham), in 1943. The significance of *H. chinatiensis* as a species with genitalic characters intermediate between *Pseudohazis* and *Hemileuca* was overlooked by Tinkham; not until Ferguson (1971) was its taxonomic position made clear. Michener (1962) combined the genera *Pseudohazis* and *Hemileuca* on the basis of their morphological similarity, but made no mention of *chinatiensis*. Although Michener included four subgenera within *Hemileuca* Ferguson chose to abandon the subgeneric names and to consider them as species groups.

It is the purpose of this paper to describe a new species of *Hemileuca* collected for the first time in 1974, and to present additional morphological evidence to support the merger of *Hemileuca* and *Pseudohazis*. The new species of *Hemileuca* described in this paper is named after Mr. Bruce Griffin, who collected the first specimens.

***Hemileuca griffini* Tuskes, new species**

Holotype: Male (Figs. 1a,b). **HEAD:** Eyes dark brown. Frontal and vertex hairs rust red, clypeal hairs dark brown to rust red. Antennae, bipectinate, 0.67 cm long; shaft orange ventrally, dark brown dorsally, pectiniform processes black and finely plumose. **THORAX:** Dorsally clothed with black hairs; long white hairs mixed with tufts of rust red hairs at base of secondaries. Collar, white with rust

red hairs anteriorly and posteriorly. Legs, clothed with black hairs; anterior portion of pro- and metathoracic legs with long rust red hairs. ABDOMEN: Abdominal segments I-VI lustrous black, posterior margin of pleura I-VI lightly fringed with white hairs. Terga I-VI black and sparsely clothed with red hairs. Terga VII and VIII rust red. FOREWINGS: 2.54 cm long, wings approximately 60% white and 40% black. Veins black. Marginal area black, submarginal area white, but traversed by black veins; postmedial line black and continuous. Distal portion of discal cell with black band extending from postmedial line to costa. Coastal area black. Area between costa and subcostal area adjacent to discal cell white. Antemedial line black and extending from costa, curving out at base of discal cell and continuing transversely to hind margin. Basal patch tear-shaped, black and free standing. Basal portion below basal patch clothed with long black and white hairs to hind margin of wing. Ventral surface similar to dorsal. HINDWINGS: 1.87 cm long and approximately 50% white and 50% black. Marginal and submarginal areas similar to those of primaries. Postmedial line diverging in area of the discal cell, forming a circular area with a white center just distal to the discal cell. Basal area black, clothed with long black and white hairs extending almost to the postmedial line along the interior margin of wing. MALE GENITALIA: (Fig. 5) Uncus trilobed, dorsal and anterior portion covered with bristles; wide at base, narrowing at apex. Lateral process of transtilla narrow, and not extending past apex of uncus. Transtilla fused, but with shallow groove at apex of medial process. Valves prominent and distinctly winged, apex slightly rounded and not pinnacle-shaped; upper half of ventral margin heavily setose. Four-eight setae $\frac{3}{4}$ as long or longer than juxta, located basolaterally. Entire genitalic structure lightly sclerotized.

Allotype: Female (Figs. 2a,b). HEAD: Eyes dark brown. Entire head covered with rust red scales. Antennae, bipectinate, 0.70 cm long; shaft orange both dorsally and ventrally pectiniform processes orange to dark brown, and not finely plumose. THORAX: Dorsally clothed with black hairs, long white hairs at base of primaries and secondaries. Long, large tufts of orange hairs at base of secondaries. Orange hairs scattered on posterior portion of thorax. Collar rust red. Legs, similar to those of male, but with more red present on femur of metathoracic leg than on holotype. ABDOMEN: Abdominal segments I-VII lustrous black with terga I-VII lightly fringed with rust red hairs. Terga of segment VIII rust red. Pleura I-VIII lustrous black. FOREWINGS: 2.83 cm long. Similar to those of male, but with the following exceptions: Marginal area more heavily marked with black scales. Black margin continuous around entire wing. HINDWINGS: 2.04 cm long. Similar to those of male but margins more heavily marked with black scales.

PARATYPE VARIATION. The length of the forewing in the 20 males examined averaged 2.54 cm, and ranged from 2.31 to 3.14 cm. The markings on the forewings exhibited little variation, except for the black basal patch. In some individuals the basal patch is slightly more prominent than that of the specimen illustrated (Fig. 1), but in 15 of the 21 paratypes examined it was less developed or almost absent. Although the pattern is uniform, the intensity of the scales differ. The wings of what are assumed to be older specimens are cream colored, rather than white, and often partially transparent. The hindwings show more variation than the forewings. Paratypes from Mexican Hat and Bitter Springs Rd. appears similar, but two males from Pierce Ferry Rd. are much darker. The forewings of 16 females examined averaged 2.75 cm, and ranged from 2.67 to 3.13 cm in length. As in the males the

forewings showed relatively little variation, but the hindwing differed markedly. In most individuals the hindwings were approximately 50% black and 50% white, while in others they were about 80% black.

Types: HOLOTYPE: ♂ ca. 6 mi. S.W. of Mexican Hat, San Juan Co., Utah. Elev. 4800'. Sept. 2, 1974. Bruce Griffin, Collector. ALLOTYPE: ♀ ca. 0.5 mi. E. of Jct. 89A and 89 on Hwy 89, near Bitter Springs. Coconino Co., Arizona. Elev. 5200'. Collected as 3rd instar larva by B. Griffin and Ken Hansen on *Coleogyne ramosissima*, May 3, 1975, and reared to maturity on *Cercocarpa betuloides* by Paul Tuskes, emerged Oct. 12, 1976. PARATYPES: Utah: 3 ♂♂, same data as holotype, 4 ♂♂ and 3 ♀♀ same locality as type, Sept. 8, 1976, Kilian Roever; 8 ♂♂ and 4 ♀♀, Rt. 163, 7 mi. S.W. of Mexican Hat, San Juan Co., Sept. 8, 1974, K. Roever. Arizona: 3 ♂♂ and 5 ♀♀ same data as allotype; 2 ♂♂ and 3 ♀♀, Pierce Ferry Rd., 32 mi. N.E. Rt. 83, Mohave Co., K. Roever; 2 ♀♀, Rt. 160, 42 mi. E.N.E. of Keyenta, Navajo Co., Sept. 8, 1974, K. Roever.

The types were deposited at the Los Angeles County Museum of Natural History. Paratypes were deposited at the following institutions: American Museum of Natural History, Los Angeles County Museum of Natural History, Dept. of Entomology, University of California, Davis, and the United States National Museum.

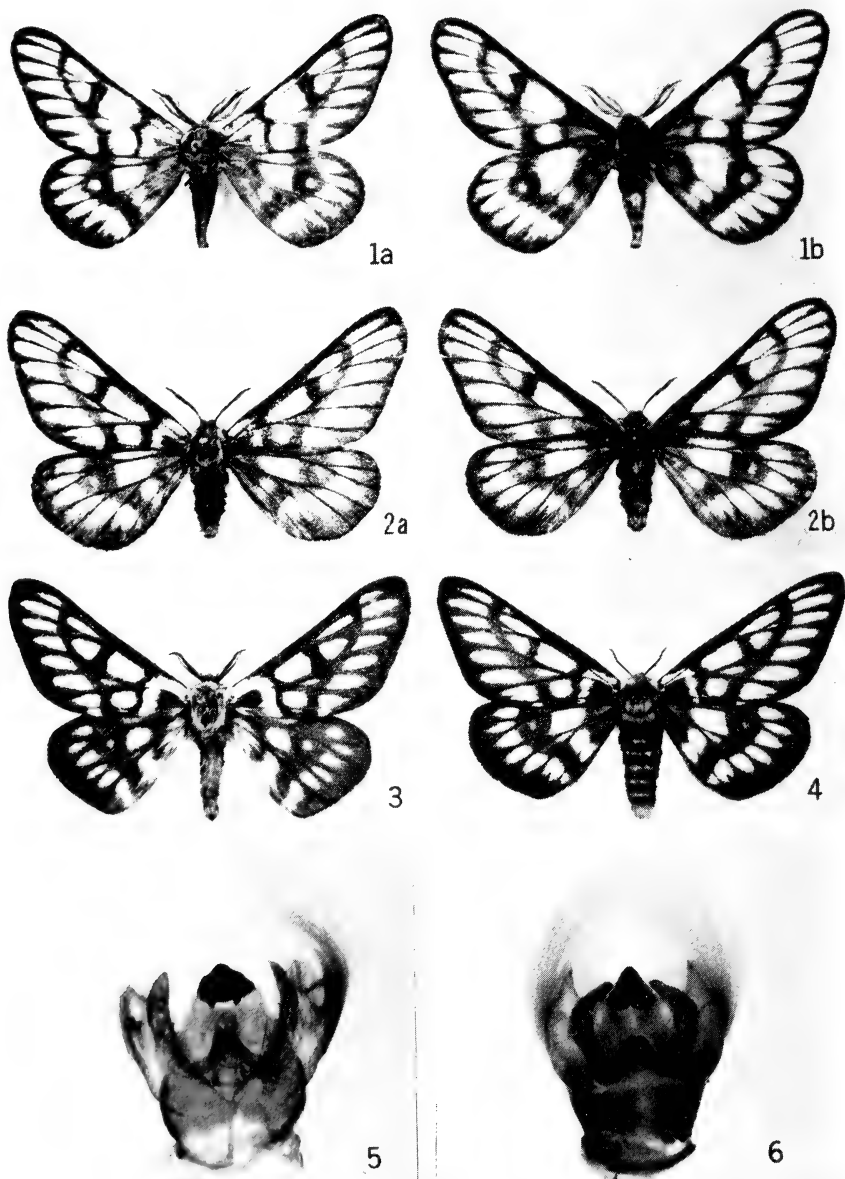
Larval Description—Last Instar

Head: Shiny black with numerous white setae, diameter, 4–5 mm. Clypeus black. **Body:** Length 45–55 mm, width, 7–8 mm. Ventral surface gray to light brown with an orange cast. Sublateral scoli black; lateral scoli black with slight yellow cast at tips, dorsal scoli of rosette type, yellow with black center. Body with three distinct lateral cream to white bands. Band I from prothoracic segment to caudal segment, passing through sublateral scoli. Band II broken by intersegmental area and located slightly ventral to lateral scoli. Band III lightly pigmented broken band, but still obvious, located midway between dorsal and lateral scoli. Segmental area with cream to white colored paniculum, especially common on lateral areas. Secondary setae white. True legs black. Prolegs gray to black. Spiracles orange. Ground color black.

Characteristics of *H. griffini* in relation to other *Hemileuca*

The trilobed uncus of *griffini* (Fig. 5) is typical of the *Pseudohazis* group. The only *Hemileuca* to have a trilobed uncus outside of the *Pseudohazis* group is *H. electra* Wright. The uncus of *electra* is typically bilobed, but apparently some aberrant males have trilobed unci (Ferguson, 1971). The transtilla of *griffini* is shallowly grooved at the apex of the medial process, and this characteristic appears to be intermediate between the two subgenera. Fused transtilla are common to all *Hemileuca* with the exception of *diana* and *grotei*. Both of these species have bilobed transtilla which are rounded and short compared to the long thin bilobed structure of *Pseudohazis*. The valves of *griffini* are prominent and distinctly winged, showing much greater development than the typical rounded valves of *Pseudohazis* but they are not as large as those of most *Hemileuca*.

The genitalia and adult phenotype of *griffini* show the greatest



Figs. 1-6. 1, Dorsal (1a) and ventral (1b) view of male *H. griffini* (Holotype). 2, Dorsal (2a) and ventral (2b) view of female *H. griffini* (Allotype). 3, Dorsal view of male *H. chinatiensis*. 4, Dorsal view of female *H. chinatiensis*. 5, Male genitalia of *H. griffini* (Holotype). 6, Male genitalia of *H. chinatiensis*.

similarity to those of *chinatiensis* (Figs. 3, 4 & 6). In *griffini*, the medial process of the transtilla is frequently less sclerotized and not as stout as that of *chinatiensis*. In addition, the medial process appears narrower at the tip, with a slightly deeper groove than that found in *chinatiensis*. The apices of the valves are variable: most are rounded, while others have a more prominent constriction similar to, but less developed than, those of *chinatiensis*.

Adult *griffini* are 25% smaller than those of *chinatiensis*. Phenotypically *griffini* males (Figs. 1a,b) can be distinguished from those of *chinatiensis* (Fig. 3) in several ways: The basal black patch on the forewing of *griffini* is usually free standing or almost absent, while in *chinatiensis* the patch continues uninterrupted to the hind margin of the wing. On the dorsal surface of *chinatiensis* the area between the costa and radius adjacent to the discal cell is black while in *griffini* there is a white patch between the costa and radius adjacent to the discal cell. The veins proximal to the post medial line in *griffini* are narrow and usually black; the veins of *chinatiensis* are also black, but the scaling diffuses out from the veins giving them the appearance of being 3 to 4 times wider than those of *griffini*. The black margin of the forewings of *chinatiensis* is from $\frac{1}{2}$ to $1\frac{1}{2}$ times wider than that of *griffini*. In general, the wings of *griffini* are approximately 40% black and 60% white while in *chinatiensis* they are about 60% black and 40% white. The dorsal portion of the abdomen of *griffini* may be covered with long rust red and/or black hairs. Thus, the abdomen may vary from black to light orange, with prominent rust red fringe around the anterior portion of each tergum. The last two segments are covered with long red hairs which form a tuft. The abdominal terga of *chinatiensis* are a uniform rust red in color. These are but a few of the characters which may be used to separate *griffini* males from those of *chinatiensis*.

Although the males of *griffini* and *chinatiensis* are very distinct, the females are similar, with only a few obvious differences. The red abdominal banding, prominent in *chinatiensis* females (Fig. 4), is less developed or absent in *griffini* (Fig. 2). In *griffini* the red hairs are mixed with black hairs and spread randomly over the entire terga but become more abundant near the pleura, giving a diffused red appearance to the lateral surface, or the abdomen may be completely black except for the presence of short red hairs at the tip of the abdomen. At present *griffini* and *chinatiensis* are thought to be allopatric, with the closest population of *chinatiensis* occurring 350 to 400 miles to the southeast, in western Texas.

Examination of last instar *griffini* larvae indicated that they are similar

in most respects to *Hemileuca*. That is, secondary setae frequently, but not always, arise from a pinaculum which is either white or cream colored. Of 36 larvae examined, 31 had white pinacula, the remainder were colored, giving them an appearance similar to that of *Pseudohazis*. Thus, although most individuals appear similar to larvae of *chinatiensis*, some individuals appear similar to *H. hera* (Harris). After examination of the larvae of 16 of the 17 species of *Hemileuca* occurring north of Mexico, this character has been found to be variable only in the larvae of *griffini*.

The two genera, *Hemileuca* Walker, 1855 and *Pseudohazis* Grote & Robinson, 1866 were joined by Michener in 1952. Michener based his decision on external morphological characters. Ferguson (1971) showed the intermediate characteristics of *chinatiensis* in which the genitalia are similar to *Hemileuca* but the adult phenotype is that of *Pseudohazis*. With the discovery and description of *griffini*, a second species with intermediate adult and larval characters has been found. The genitalia of *griffini* are more similar to genitalia of males of the *Pseudohazis* group than those of *chinatiensis*. In addition, the larvae of *griffini* exhibit morphological characters common to both species groups. Thus, a continuum of adult and larval characters exists between the two previously separated genera, *Hemileuca* and *Pseudohazis*.

ACKNOWLEDGMENTS

I would like to thank Mr. Bruce Griffin and Mr. Kenneth Hansen both of Tucson, Arizona, and Mr. Kilian Roever and Mr. Michael Van Buskirk of Phoenix, Arizona, for providing distributional data and/or specimens.

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THE STATUS OF *OLLIA PARVELLA* DYAR: REDESCRIPTION OF IT IN A NEW GENUS (PYRALIDAE)

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ABSTRACT. *Ollia parvella* was described from females only. The discovery of a few males shows that it is not a Peoriine but a Phycitine and that it belongs in a new genus: *Welderella*.

When Shaffer (1968) revised the North American Anerastiinae (Auctorum), he grouped the majority of the species in the subfamily Peoriinae and returned most of the remaining ones to the Phycitinae. A few genera and species remained unplaced and were listed as such at the end of his revision. Blanchard and Ferguson (1975) included three of these unplaced species in the new phycitine genus *Rostrolaetilia* together with seven new species which were described in the same paper.

Ollia parvella Dyar is another species which Shaffer could not place, in this case because no male was available. My wife and I took six specimens of this species (4 males and 2 females) 3 and 5 July 1975 at the Welder Wildlife Foundation Refuge. Through the courtesy of Dr. D. C. Ferguson I was able to borrow from the National Museum two paratypes of the six females which constitute the type series. The comparison of the genitalia of one of my females (slide A.B. 3879) with those of one paratype (slide U.S.N.M. 52945) leaves no doubt that my specimens are conspecific.

As Shaffer had suspected, an examination of the male genitalia shows that this species is a Phycitine, although nothing closely related is included in Heinrich's revision of this subfamily (1956). *Ollia* is a synonym of *Peoria*, not a Phycitine genus. Obviously a new genus is needed.

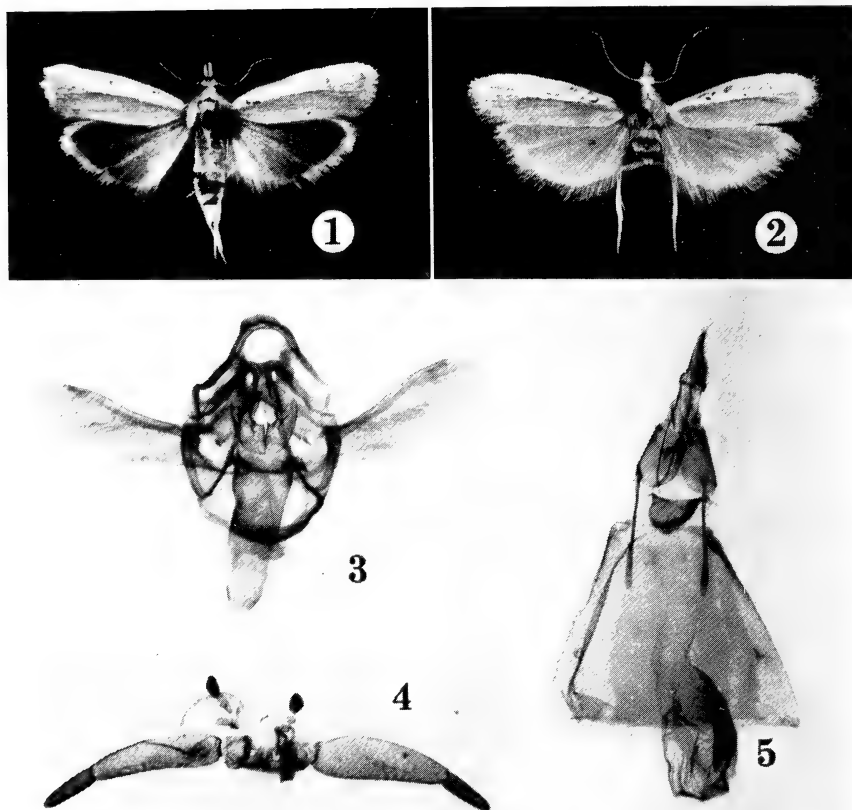
Welderella A. Blanchard, new genus

Type species: *Ollia parvella* Dyar (Figs. 1, 2, 4, 6).

Labial palpi porrect, downcurved, extending over three times eye diameter beyond front, loosely scaled; from beneath seen to be in contact with each other for nearly all their length; second segment two and a half times longer than the third. Maxillary palpi short, squamous. Antennae simple. No ocelli.

Forewing smooth, broadest at two thirds distance from base to apex; apex and tornus rounded. Cell about two thirds length of wing. Venation somewhat variable, 10 or 11 veins: R_2 , R_4 and R_5 normally united, but two specimens show on one wing R_5 separating from R_{3+4} as a faint spur; M_2 and M_3 stalked for about two fifths their length; Cu_1 from lower outer angle of cell; Cu_2 from near the angle.

Hind wing: length of cell ill defined (discocellular vein obsolete) but apparently slightly longer than half the length of the wing; Sc and Rs long stalked, Sc separates from Rs as short spur going to costa, Rs continues to near apex; M_1 straight to

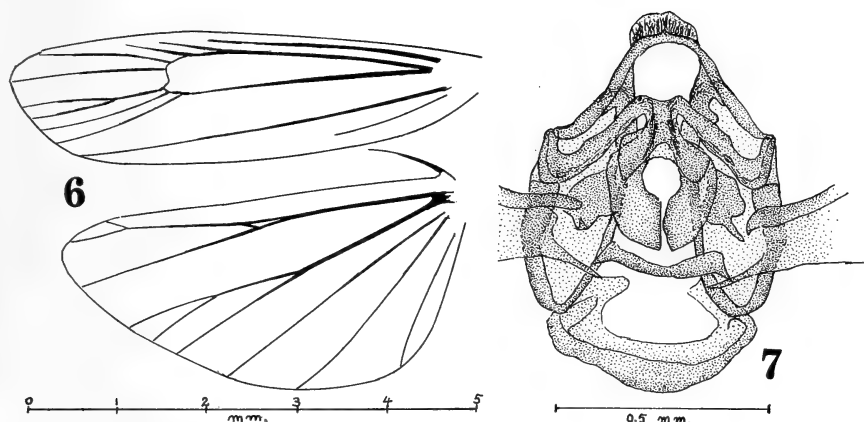


Figs. 1-5. *Welderella parvella*: 1, male; 2, female; 3, male genitalia; 4, denuded labial and maxillary palpi, showing rudimentary tongue; 5, female genitalia.

outer margin; M_2 absent; M_3 and Cu_1 stalked for about half their length; Cu_2 in almost exact prolongation of cubitus.

Male genitalia (Figs. 3, 7): Uncus triangular; apex produced, rounded, covered with bristles. Gnathos stout, with very large flanged apical processes; the lobes fusing posteriorly. Aedeagus smooth, moderately stout, about three times as long as maximum width, vesica without cornuti. Tegumen with strong supporting structure forming on each side a wide U, with one branch supporting the gnathos and the other the dorsal processes of the uncus. Vinculum mostly membranous, supported in part by the tegumen and the shallow, wide, well sclerotized saccus. Transtilla incomplete, represented by a pair of irregularly shaped plates. Juxta with anterior margin heavily sclerotized. Valves simple, without clasper; sacculus narrow and short.

Female genitalia (Fig. 5): bursa and ductus bursae membranous; ductus bursae rather wide, broadening progressively into pear shaped bursa; signum well sclerotized, longitudinally infolded; some weak scobinations around it; ductus seminalis from left side of signum; genital opening wide, funnel shaped, sclerotized and scobinate ventrally.



Figs. 6, 7. *Welderella parvella*: 6, venation; 7, enlarged part of male genitalia.

This genus shares characters with two widely separate groups of Phycitine genera. The male genitalia suggest that it should go near *Laetilia*: the uncus, the gnathos, the transtilla are quite similar, but the complete absence of ocelli and the longitudinal wing pattern point to a placement near *Bandera* and *Tampa*.

I take great pleasure in naming this new genus for the Welder Wildlife Foundation, for its staff, whom I have always found ready to help me in every way and for its generous founders, the late Rob Welder and his wife Bessie Welder.

Welderella parvella (Dyar)

Dyar, 1906, p. 31. Barnes & McDunnough, 1917, p. 149. McDunnough, 1939, p. 36. Kimball, 1965, p. 250. Shaffer, 1968, p. 89.

The original description reads: "Costal half of fore wing white with slight darker lines on the veins toward apex. Inner half pale ocherous, shading to gray next to white part. Hind wing whitish." The Welder Wildlife Refuge females match this description, but the hind wing of the male is whitish only in the one third of it along the inner margin; the other two thirds are blackish gray.

Wing expanse: males 12.5–14 mm., females 13–15.5 mm.

Type data: I have not examined the holotype, a female from Brownsville, Texas, June 3 (?), 1904, H.S. Barber, U.S.N.M. type No. 9103; genitalia slide No. 10, Carl Heinrich, Dec. 20, 1932.

Specimens examined: Brownsville, Texas, 31 May 1904, 1 ♀; 8 June 1904, 1 ♀; (Slide U.S.N.M. No. 52945), both collected by H.S. Barber. Welder Wildlife Foundation Refuge, 3 July 1975, 2 ♂♂ (slides A.B. 3894, 3854, 3890; these last two slides are all that remains of one of these males), 5 July 1975, 2 ♂♂,

2 ♀ ♀ (♂ slide A.B. 3857, ♀ slide A.B. 3879), all collected by A. & M. E. Blanchard.

ACKNOWLEDGMENTS

I am indebted to Dr. D. C. Ferguson for arranging the loan of two female paratypes from the National Museum collection and to Dr. J. C. Shaffer for revising the manuscript.

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BIONOMIC NOTES ON THE BLOOD-SPOT SKIPPER
[HESPERIIDAE: *PHOCIDES LILEA SANGUINEA* (SCUDDER)]

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ABSTRACT. Observations on the life cycle of *Phocides lilea sanguinea* are reported. An additional larval foodplant, notes on egg and larval stages, and adult oviposition behavior are described.

Phocides lilea sanguinea (Scudder) is a large-sized skipper which exhibits a metallic blue background with a prominent red spot on each dorsal forewing. Basically a tropical species, *sanguinea* has established breeding populations in the Brownsville, Cameron County, Texas area. This population has been known as *Phocides polybius lilea* (Reakirt) but H. A. Freeman (*in litt.*) prefers treatment of *lilea* at the species level with subspecific rank being accorded *sanguinea*. My initial interest in this species arose because of the significance of establishment of permanent populations on non-native larval foodplants. Field observations have yielded various new bionomic facts concerning this insect.

The only plant previously known to support larvae of *sanguinea* in either the United States (Lipes, 1961) or Mexico (Comstock and Vasquez, 1961; Kendall and McGuire, 1975) is common guava, *Psidium guajava* (Myrtaceae). My observations in Brownsville have revealed that a congeneric plant, *Psidium cattleianum* Sabine (strawberry guava) is also utilized as a larval foodplant by *sanguinea*. Identification of the foodplant was verified using comparative herbarium specimens and characters given by Bailey (1949: 729). All references below to *Psidium* refer to *P. cattleianum*.

Newly-laid eggs are a pale but distinct aqua in color. A glistening wet appearance is noticeable for several minutes following oviposition. Within eighteen hours of oviposition, the contents of the egg begin to turn reddish as embryogenesis proceeds. Red coloration appears initially as individual foci which enlarge until the whole egg appears red. Similar egg color changes during development have been reported in *Agathymus* (Roever, 1964). This red color involves the internal constituents only, as the chorion appears whitish in color. The egg is hemispherical in shape with a diameter of approximately 1.5 mm. A hole encompassing the top one-third of the egg reveals a hatched egg. The egg shell is not eaten by the larva.

Larvae of *sanguinea* go through a dramatic change in coloration during development. First instar larvae have a bright red body similar in color to the mature egg, but the head is brownish, varying extensively in darkness. Body length is 3.0 to 3.25 mm while the head capsule measures approximately 1.0 in width. Second instar larvae are about 8.0 mm long with a head capsule of 1.5 mm in width. The head of the second instar remains basically brown but is somewhat closer in coloration to the red body color than is the head of the first instar larvae. Larvae of Mexican and South American populations of *Phocides* were reported to have yellowish intersegmental bands (respectively, Comstock and Vasquez, 1961; Miles Moss, 1949); no such bands were observed on Texas larvae. Larvae of intermediate instars were not observed. Mature larvae are whitish with a slight "bloom" similar to that reported for *Phocides pygmalion okeechobee* (Worthington) by Srohecker (1938). This "bloom" is a white, powdery exudate which is present on the body of the larva. The body also exhibits a large number of black "pin-prick" marks. The head capsule is reddish-brown with a yellowish "eyespot" on each side.

Retreats are formed by the larvae utilizing leaves of the foodplant. Miles Moss (1949) described initial shelters as "small oval, of cutleaf" while older larvae were "content to hide by day between several leaves held together by a few strands of glutinous silk." The following observations add to the above information: neither Lipes (1961) nor Kendall and McGuire (1975) mention these retreats *per se*. Immature larvae make two cuts from the leaf margin inward about five mm. This leaf section is then pulled flat over toward the midrib so that a small retreat is formed. This folded-over upper portion is then attached to the lower portion by a plug of silk. The flatness of the retreat in comparison to that formed by *Calpododes ethlius* (Stoll) on *Canna* is probably caused by the thick stiff nature of mature *Psidium* leaves as opposed to the thin, pliable leaves of *Canna*. While most retreats are formed from two leaves as reported by Comstock and Vasquez (1961), one retreat consisted of three leaves—the apical pair and one of the leaves on the penultimate node. The larva rested on the top leaf or "ceiling" in an upside-down orientation.

Mortality is extremely high in the early instars. A check of a single *Psidium* shrub yielded twenty-seven hatched eggs, but only five living first and second instar (and dead bodies of seven other) larvae in larval folds. Construction of the larval retreat is a task which many *sanguinea* larvae are not able to complete. Leaves supporting hatched eggs but no

larvae occasionally have a single cut similar to the two required to form a retreat.

Only a few chrysalids were observed during these studies. The chrysalis is loosely attached to the upper part of the retreat by silk strands. A parasitized chrysalis with many wasp (probably *Apanteles*) exit holes was found in one retreat. This chrysalis measured 28 mm in length and 8.25 mm at greatest width (second abdominal segment).

Adult female flight behavior in the vicinity of *Psidium* is quite distinctive. The imago "flits" or "skips" along and above the periphery of the bush. Suddenly the adult will drop to the level of the bush and quickly land on a leaf. Always facing outward toward the tip of the leaf, she quickly lays an egg, and flies upward and around the bush again. If undisturbed, the behavior sequence is repeated.

Although both male and female adults were observed flying, only females alighted on any substrate. All but one of these observations involved ovipositional landings on *Psidium* leaves. One female was observed to land on a leaf of a bottlebrush shrub, *Callistemon citrinus* Staph. (= *lanceolatus* DC.), which is also an introduced member of the Myrtaceae. After remaining on the leaf for about ten seconds, the adult flew off; no egg was laid. The relatively long period of time spent on the bottlebrush leaf indicates that after initial selection of a prospective plant from a short distance (about 0.5 m) in the air, confirmation of proper ovipositional substrate is required on the leaf surface. The means of confirmation is unknown at this time, but it can be made in a very short time if the substrate possesses the correct phytochemicals.

Placement of the eggs is highly predictable as a result of the rigid ovipositional behavioral sequence. Of twenty-seven egg shells found on 23 December 1970 all but one were on the upper surface of the leaf. Terminal leaves tend to be selected for oviposition. Numerical data and probable adaptive significance of this selection will be presented elsewhere.

Adults in July were observed visiting flowers of an introduced ornamental, lilac-flowered golden dew drop (Verbenaceae: *Duranta repens* L.). Adults expressed no interest in the flowers of the bottlebrush shrub tentatively selected for oviposition.

Knowledge of the seasonal presence of the various life history stages of *sanguinea* is desirable. Observations of a mature larva revealed no apparent movement or feeding during a ten-day period from Dec. 1970–Jan. 1971. Weather conditions at this time were quite mild; live eggs and immature larvae were present at the same time. In contrast, December 1976 was cold and wet; no eggs or larvae were found on the same bush at that time.

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CLIMATIC REGIMES RESULTING IN UNUSUAL OCCURRENCES OF RHOPALOCERA IN CENTRAL TEXAS IN 1968

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ABSTRACT. During 1968 several species of Rhopalocera which normally do not occur in this area (or occur only in small numbers during the latter part of the season) were abundant in central Texas. Meteorological regimes which influenced this influx of tropical species are discussed.

Central Texas is a major ecotonal area between the Nearctic and the very northern fringes of a dilute Neotropical rhopaloceran element which appears as far north as Central Texas under various climatic regimes. Some of these species may occur as far north as Kansas or Nebraska as stragglers, but breeding populations are not established. One such climatic regime occurred in 1968. Discussed below are observations made at the Brackenridge Field Laboratory of the University of Texas at Austin within the corporate limits of the city of Austin.

Heliconius charitonius vasquezae Comstock and Brown and *Dryas julia moderata* (Stichel) (both Heliconiidae) were very common in 1968 as early as June. The existence of numerous fresh specimens and the length of time during which these two species were present (well into the fall months) indicate that breeding colonies of both species had become established. At least one suitable larval foodplant, *Passiflora lutea* L. (Passifloraceae), is present on the grounds of the field laboratory. Nocturnal roosting aggregations (up to eleven individuals) of *H. charitonius* were observed at several sites within the eighty-acre area. Different sites were used at various times. Each site was a shrub or tree at the edge of a wooded area. These two heliconians are seen in the Austin area in about half the years, but they normally appear in late summer or fall indicating late season dispersal from areas to the south with permanent populations. Sporadic breeding occurs in at least some of these years as indicated by reports for both species in 1966 (Rickard, 1967, 1968).

Dynamine dyonis (Geyer) occurred commonly from July into the fall. Specimens were normally restricted to wooded areas along a dry arroyo. Breeding occurred as indicated by the fresh condition of most specimens seen throughout the season. *D. dionis* was initially reported in the Austin area in 1899 (Brues, 1905). A breeding population was established "along the bed of a dried up creek near Austin, Texas." Brues had not

seen this species before this time (time of initial observations in Austin area by Brues unknown) and did not see it during the three following years, although he collected in the same areas. As his first records were in October, this species probably immigrated into the area in late summer 1899; the progeny of these immigrants were observed by Brues. Brues (1905) records that *Mestra amymone* (Menetries) was "very common about Austin . . . in former years they were much less numerous." *M. amymone* is a permanent resident of the Austin area (Masters, 1970) but was exceptionally abundant in 1968.

Adults of *Achlyodes thraso tamenund* (Edwards) (Hesperiidae) were commonly seen resting on soil surfaces in open areas in 1968. Kendall (1965) reported this skipper from southern Texas. Records included Goliad, Kleberg, Live Oak and San Patricio Counties (all well south of the Austin area).

Hurricane Beulah struck the Texas coast near the mouth of the Rio Grande River on 20 September 1967. Torrential rains covered a large area of south Texas resulting in floods and semi-permanent ponds of water (Grozier, et al., 1968; Baker, 1971). Subsequently, many rhopaloceran species not before known from Texas (or the United States) were reported from south Texas, particularly from Cameron and Hidalgo Counties at the southern tip (Doyle, 1970; Heitzman, 1970; Heitzman and Heitzman, 1972; Kendall, 1970, 1972).

The effect of this storm upon the rhopaloceran fauna in south Texas is well-documented and was more than temporary as some species have been found in subsequent seasons (Tilden, 1974). While this storm may have been related to the unusual rhopaloceran occurrences in central Texas in 1968 in an indirect manner, the major cause involves the weather of 1968. The species involved in this temporary northward movement could have occurred in the central Texas area in late 1967 and remained undetected, but their survival of the 1967-68 winter in these latitudes is most unlikely. Coldest temperature at Austin for this winter was 22°F. which is certainly much too cold for these species to survive. Average monthly temperature for winter 1967-68 were generally below normal in southern and central Texas. If these species could survive such cold weather, these taxa would be common in central Texas during many seasons.

Torrential rains associated with Hurricane Beulah allowed the development of larger than normal populations of these species in areas closer to central Texas than is normally the case (southern Texas and/or northern Mexico). The key to the appearance of these species in early 1968 was higher than average rainfall in May 1968 at Austin (8.75" vs. normal

4.22") and many other localities in central Texas, especially along the Balcones Escarpment (scattered localities actually had lower than normal totals). Rains and cooler than normal temperatures during the summer (U. S. Weather Bureau, 1968, Climatological Data, Texas, p. 73) fostered plant growth and development of certain rhopaloceran populations. Rainfall at Austin in summer 1968 was 18.5% above normal and high temperature was only 98°F.

Population movements from south Texas or, more likely, from northern Mexico along the Balcones Escarpment was initiated by large resident populations; survival of these populations was allowed by favorable moisture conditions. None of these forms was seen in central Texas in early 1969 (low temperature during 1968-69 winter was 22°F.).

A second northward movement was observed in fall 1968. These movements may have involved species more common in northern Mexico at the end of the rainy season. Population development in northern Mexico probably reached levels such that northward population movements ensued. Climatic conditions of central Texas may not have been significant in the occurrence of the following form as no evidence of reproduction in these relatively northern areas is known. Rainfall in the Border Country of Texas was up to twice normal during this fall period (Posey, 1968; Wagner, 1969).

Colias (Zerene) cesonia (Stoll) is one of the common species in Austin, particularly in spring and fall. This species is normally represented in central Texas by the nominate subspecies which exhibits a reasonably obvious "dog face" even in the female. Several female specimens of *C. cesonia* collected during October 1968 exhibited a different phenotype, *immacusecunda* Gunder, with greatly reduced black markings on DFW and DHW. Originally described as a "form ♀" (Gunder, 1928), this form has been treated as an aberration by some authors (Brown, 1965). I believe this form represents a normal (seasonal?) phenotype present in certain populations in Mexico (Neck, pers. obs.). Under certain climatic conditions this form moves northward into Texas.

Other observers reported occurrences of tropical or sub-tropical species in the central Texas area in 1968. *Biblis hyperia aganisa* Boisduval was seen in San Antonio, Bexar County by W. Tyron on 7 October 1968 (Tilden, 1974), Kendall (1972) reviewed the occurrence of the tropical heliconian, *Eueides cleobaea zorcaon* (Reakirt), in southern Texas as far north as San Antonio in 1968.

In an attempt to verify that a particular climatic regime was responsible for the occurrence of the above butterflies in central Texas, weather records for 1899 and 1966 were consulted to determine if peculiar climatic

conditions existed at the time of previous occurrences in central Texas of some of the above species.

In 1899, statewide precipitation in Texas was about normal, being 94% of average, but summer precipitation was high, 131% of average (Norquest, 1941). Precipitation records for particular stations for 1899 are not published in readily available form. However, a massive rainstorm occurred in late June 1899 in central Texas. This storm, which produced the worst flood on record for the Brazos River, was centered north of the Austin area, producing over thirty inches of rain in certain areas (Texas State Almanac, A. H. Belo Corp.). If rain from this storm was distributed, albeit in smaller amounts, to the south, then this storm with its attendant rainfall and wind circulation could have been involved in the occurrence of *D. dyonis* in central Texas in 1899. Ironically the occurrence of the subtropical butterfly *D. dyonis* in central Texas in autumn 1899 followed the most severe Texas winter on record. Record low temperatures were recorded at various stations including 12°F. on 13 February at Brownsville at the southern tip of Texas. Central Texas temperatures were at or below 0°F. Brues (1905) remarked that "the summer had been very favorable for the development of insects as Hymenoptera and Diptera were more abundant than I have ever seen them in that part of the country."

Occurrence of breeding *H. c. vasquezae* and *D. j. moderata*, in central Texas in October 1966 (Rickard, 1967, 1968) probably resulted from heavy rains in August of that year. Following below normal rainfall during the first seven months of 1966, August was excessively wet for both Austin (6.21" vs. normal 2.17") and San Antonio (4.28" vs. normal 2.25"). Such a large influx of moisture is quite sufficient to cause rapid vegetative growth and large scale movements of various butterfly populations.

Environmental changes over large areas such as southern Texas and northern Mexico provide natural experiments which reveal factors which control the extent and abundance of occurrence of particular species (see earlier report by Gilbert, 1969). Obviously, two major climatic regimes of present-day central Texas prevent the establishment of a fringe Neotropical fauna: insufficient rainfall and relative extreme winter cold.

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A NEW NAME FOR *PAPILIO CERES* CRAMER, [1776],
NEC FABRICIUS, 1775 (NYMPHALIDAE, DANAINAE)

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ABSTRACT. *Lycorea pieteri*, *nomen novum*, is proposed as a replacement name of *Papilio ceres* Cramer, [1776], pre-occupied by *Papilio ceres* Fabricius, 1775.

Papilio ceres, a danaine described by Cramer ([1776]: 141, 152, pl. 90, fig. A) from "Surinam" is a junior primary homonym of *Papilio ceres* Fabricius (1775: 504), an African nymphaline. The only author who seems to have noticed this homonymy is Billberg (1820: 77). Under his new genus *Epimetes*, Billberg introduced the name *sebethis*, as follows:

Sebethis Brasil. Eg. *Ceres* Fbr.

As can be surmised from other examples elsewhere in his work, the above notation indicates that Billberg was proposing his name *sebethis* as a substitute for *ceres* Fabricius, and that he had a specimen (or specimens) from "Brazil" in his collection (Eg. = *Auctor hujus operis*). What is not clear is if Billberg considered *ceres* Cramer to be the senior name, or if he intended to write "Cr." instead of "Fbr." after *ceres*, and just made a *lapsus calami*. However, in at least one other instance, Billberg gives preference to a junior Cramerian name over a Fabrician one, under the genus *Amaryssus* Dalman (*minos* Cramer, [1780] versus *astenuous* Fabricius, 1775).

Whatever Billberg's true *intention* was, it is his *action* which counts here, and the result was the unfortunate introduction of an invalid junior synonym of *Papilio ceres* Fabricius (currently known as *Najas ceres* (Fox *et al.*, 1965) or *Euphaedra ceres* Auct.; the correct nomenclatorial status of this species is not yet settled, *cf.* Cowan, 1974).

Therefore, *Papilio ceres* Cramer still needs a replacement name, and under the provisions of Article 60(b) of the International Code of Zoological Nomenclature I hereby propose *pieteri*, in the combination *Lycorea pieteri*, *nom. nov.* This name is a masculine noun after the patronym of Pieter Cramer.

ACKNOWLEDGMENTS

Mr. William D. Field, Smithsonian Institution, kindly read and com-

mented on the manuscript. This paper was prepared during the tenure of a post-doctoral fellowship at the National Museum of Natural History, Smithsonian Institution.

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TWO NEW PINE-FEEDING SPECIES OF *COLEOTECHNITES* (GELECHIIDAE)

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ABSTRACT. Two new species of moths, *Coleotechnites ponderosae* and *C. edulicola* (Gelechiidae), whose larvae mine needles of pinyon and ponderosa pine, are described. Each is a potential pest species in Colorado and New Mexico.

Two species of *Coleotechnites* Chambers, one on ponderosa pine and one on pinyon, are pests of these important tree species. Stevens has studied both in the field, has published on the ponderosa pine species, and has a paper on the pinyon species elsewhere in this issue. An attempt at determination showed that each species is new. The senior author plans a revision of the genus *Coleotechnites*, but this work will not be completed for some years. Descriptions are presented to provide names for these species.

Coleotechnites ponderosae Hodges & Stevens, n. sp. (Figs. 1, 3, 4)

Upper surface as figured. **Head:** base of tongue mottled dark and medium gray; labial palpus with first and second segments dark gray, nearly black on lateral surface, second segment with a pale gray to white streak at $\frac{3}{5}$ length and one at apex, mesal surface white dorsally nearly to ventral margin, third segment white at base, middle and apex, dark brown to nearly black separating white areas; frons mainly white, some scales medium to dark-gray tipped; vertex and occiput with many dark-gray tipped scales above eye, bases of scales white, many with lustrous purple reflections; scape of antenna mottled white and very dark brown dorsally, white ventrally, shaft with alternating half segments of yellowish-gray and brown scales on distal three-fifths. **Foreleg:** mainly dark gray, some yellowish-white scales at apex of coxa, tibia with a few white scales at half length and at apex; base and apex of first tarsal segment white, apexes of second and third tarsal segments white. **Midleg:** similar to foreleg, some white scales at base, middle and apex of tibia, base and apex of first tarsal segment and apices of second, third, and fourth tarsal segments white to off white. **Hindleg:** coxa shining white and yellowish white with lustrous blue and purple reflections and some gray scales; femur similar with gray scales on ventral margin; tibia with white scales at base, a streak of white scales at base of first pair of spurs, and another at apex, tibial spurs pale gray to off white, dorsal scale tuft yellowish white; tarsus with base and apex of first segment, apices of second, third, and fourth segments yellowish white, other scales medium to dark gray brown. **Wing length:** 3.9-4.8 mm. **Forewing:** upper surface mottled brown and white, scale bases white, fringe yellowish white in tornal area. **Hindwing:** upper surface yellowish gray, fringe slightly more intense yellowish gray; male with hair pencil of yellow to yellow-brown scales on posterior margin at base. Ventral surface of wings mainly yellowish gray. **Abdomen:** dorsal

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Fig. 1, 2. Adult *Coleotechnites*. 1, *C. ponderosae* ♂, holotype; 2, *C. edulicola* ♂, holotype.

surface shining yellow and yellowish gray with lustrous yellow and purple reflections, male with yellowish-orange sex scales on segments 1-3; ventral surface mainly shining gray, male with some white to off-white scales at apexes of segments 4-8, female mainly darker gray. **Male genitalia:** as in Fig. 3; valvae asymmetrical, right valva curved apically, left valva nearly straight, apex strongly curved; aedeagus ankylosed with vinculum, apex reaching level of apexes of lobes of sicae; lobes of sicae directed to left from middle to near apex, apex of right lobe turned posteriad; tegumen with asymmetrical posterolateral lobes, right lobe slightly smaller than left lobe; gnathos slender, hooked apically; uncus with posterior margin smoothly indented medially. **Female genitalia:** as in Fig. 4; anterior margin of eighth segment heavily sclerotized; base of *ductus bursae* slightly more heavily sclerotized than rest of *ductus bursae*; *ductus seminalis* arising two-fifths length from base; corpus bursae gradually expanded from *ductus bursae*; single signum with two, inwardly directed projections nearly parallel sided for distal third, margins with small serrations.

Foodplant: *Pinus ponderosa* Lawson. The larvae are needle miners. The life history has been published by Stevens (1973).

Types: **Holotype:** ♂. Boulder, Colorado; July 1971; Hopkins No. US 36711; *Pinus ponderosa*, J. Staley; USNM type number 75471. **Paratypes:** 6♂♂, 8♀♀. Same data as for holotype; USNM genitalia slides 10136, 37, 39–41, USNM.

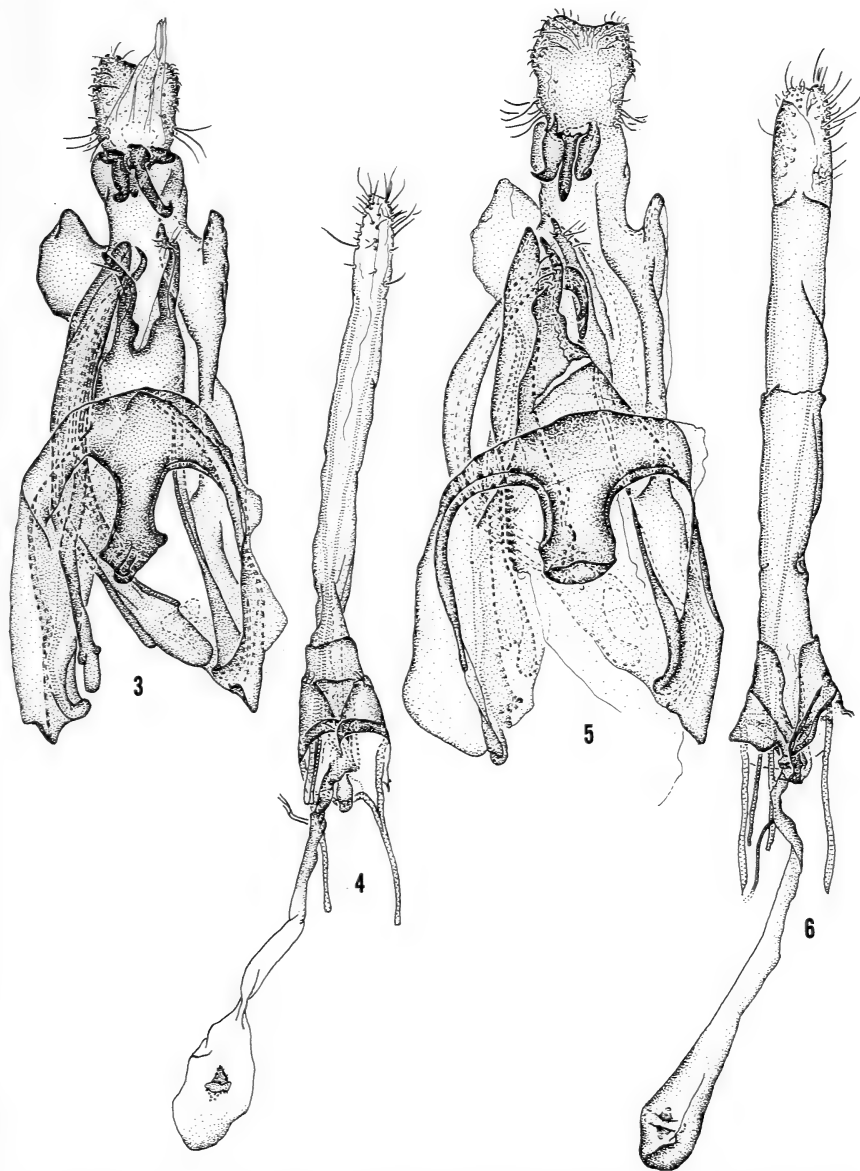
Superficially, *ponderosae* is similar to the type specimen *moreonella* (Heinrich); however, the wing length of *moreonella* is 6.2 mm, and the basal segments of the antenna of *moreonella* are wider than long; those of *ponderosae* are longer than wide. In the male genitalia the left valva of *ponderosae* is very slender apically, and the apex is at a right angle with the long axis; that of *moreonella* is stouter, and the distal third is slightly curved. *Coleotechnites ponderosae* males have sex scales on terga 1–3; *moreonella* males have them on segments 1–4.

Specimens in the type series vary in the number of dark-brown tipped scales but generally all are dark brown as seen with the naked eye. Worn specimens are paler brown.

***Coleotechnites edulicola* Hodges & Stevens, n. sp.**

(Figs. 2, 5, 6)

Upper surface as figured. **Head:** tongue mainly white with some gray scales at base; labial palpus white at extreme base, lateral surface of first segment dark gray beyond base to apex, mesal surface white, second segment mainly dark gray from base to half length and with some dark gray-brown tipped scales at three-fourths length laterally, a white band at half length and at apex, mesal surface mainly white with some dark gray-brown scales on ventral margin, third segment mainly white with a narrow brown band at half length; frons with dark-gray scales in front of eye and on ventral half, dorsal part shining white to yellowish white; vertex and occiput mainly white to yellowish white, many, scattered scales with gray apices, with some lustrous yellow and purple reflections; scape of antenna mainly white to yellowish white, some gray-brown scales on dorsal surface before apex, shaft alternating half segments of yellowish-gray and dark-gray scales. **Foreleg:** coxa mainly dark gray with some yellowish-gray scales, femur darker gray brown with some white-tipped scales at half length and on dorsal margin; tibia dark brown with white scales at one-fifth length, one-half length and at apex; tarsus dark brown, base and apex of first segment and apex of second segment with white scales, third and fourth segments with some pale-gray scales at apices. **Midleg:** coxa shining yellowish white with lustrous yellow and purple reflections; femur mainly dark gray, some yellowish-gray scales at base and one-half length and some yellowish-white scales at apex; tibia dark gray brown, white at base, one-fifth length, three-fifths length and at apex; tarsus dark brown, base and apex of first and apices of rest of segments white. **Hindleg:** coxa shining yellowish white and pale gray with lustrous yellow and purple reflections; femur white on dorsal margin, dark gray with lustrous yellow and purple reflections on rest; tibia with a broad white streak from base to nearly one-third length, a white streak at three-fifths length, apex white, rest of segment dark gray brown, dorsal scale tuft medium to dark gray, outer tibial spurs white, inner tibial spurs gray with white apices; tarsus mainly dark gray brown, base and apex of first segment and apices of rest of segments white. **Wing length:** 4.4–5.2 mm. **Forewing:** upper surface mottled dark brown and white, fringe shining yellowish gray. **Hindwing:** gray, fringe shining yellowish gray, a yellow to yellowish-brown hair pencil on posterior margin at base.



Figs. 3–6. Genitalia of *Coleotechnites* spp. 3, *C. ponderosae* ♂; 4, *C. ponderosae* ♀; 5, *C. edulicola* ♂; 6, *C. edulicola*.

Abdomen: ♂ with first three terga having yellow sex scales, other segments pale yellowish gray, posterior margin of each segment paler, nearly white; ventral surface mainly medium gray, posterior margin of most segments yellowish white to white; ♀ much as for ♂ except lacking yellow sex scales. **Male genitalia:** as in Fig. 5;

right valva curved at right angle at one-half length and again at four-fifths length, distal one-fifth in nearly same direction as basal half; left valva slender, tapering gradually to acute apex; aedeagus extending slightly beyond apexes of sicae; tegumen with pair of asymmetrical lobes on posterolateral margins; uncus broad, posterior margin slightly indented medially. **Female genitalia:** as in Fig. 6; anterior margin of eighth abdominal segment heavily sclerotized, anterior margin of eighth sternum extending anteriorly to level of anterior margin of eighth tergum; *ductus bursae* slender with a sclerotized band on basal one-fifth; *ductus seminalis* arising at one-fourth to one-third length; *corpus bursae* expanded gradually from *ductus bursae*; signum with pair of inwardly directed lobes; margins of each lobe very slightly serrate.

Foodplant: *Pinus edulis* Engelm. The larvae are needle miners.

Types: **Holotype:** ♂. 14 Km N Aztec, New Mexico; 6/73; *Pinus edulis*; coll. R. Stevens; Hopk. U.S. 36741; USNM type no. 75472. **Paratypes:** 12 ♂♂, 3 ♀♀. Same data as for holotype; USNM genitalia slides 3512-4, 10133-5, USNM.

Coleotechnites edulicola is very similar to *ponderosae*, but the forewings are much paler. To the naked eye *edulicola* is a pale species; *ponderosae* is a medium to dark gray-brown species. In *edulicola* the right valva has two right angles, that of *ponderosae* is broadly curved and the apex is at a right angle with the preceding part. Females of *edulicola* have the anterior margin of the eighth abdominal sternum extending anteriorly as far as that of the anterior margin of the eighth tergum; females of *ponderosae* have the anterior margin of the eighth abdominal sternum posterior of the anterior margin of the eighth tergum.

Specimens in the type series vary somewhat in the relative amounts of dark-brown and white scales. *Coleotechnites edulicola* has also been reared from *Pinus edulis* at Santa Fe, and Nageezi, San Juan County, New Mexico.

ACKNOWLEDGMENTS

We are indebted to Ann R. Richardson for the line drawings of the genitalia and to Victor Kranz for the photographs of the adults.

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LIFE HISTORY AND HABITS OF *COLEOTECHNITES*
EDULICOLA (GELECHIIDAE) A PINYON NEEDLE
MINER IN THE SOUTHWEST

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ABSTRACT. *Coleotechnites edulicola* infests needles of pinyon, *Pinus edulis* Engelm., in the southwestern United States. The species is univoltine. Moths fly in June and July, and eggs are laid inside previously mined needles. First-stage larvae bore into green needles, feed within them, and overwinter there as 2d and 3d instars. The insects pupate in late spring. Persistent infestations can cause severe defoliation and presumably weakening and mortality of heavily infested trees. Several eulophids and pteromalids, and a single species of braconid, are recorded as associates.

During summer 1973, our attention was called to a population of needle miners causing heavy defoliation to pinyon (*Pinus edulis* Engelm.) in the Animas Valley north of Aztec, San Juan County, New Mexico, and on the Colorado side of the state line in La Plata County. We knew that pinyon needle miners are occasionally reported from the Southwest; the Aztec infestation offered an opportunity to make observations on the life history and habits of the species.

Needle miners have received relatively little attention in western North America. Freeman (1960) reviewed those of the entire continent, discussing 23 species of gelechiids, yponomeutids, and tortricoids, mainly from a systematic standpoint. The only ones that have been studied in much detail in the West are two species of *Coleotechnites* (Gelechiidae) infesting lodgepole pine, *P. contorta* Dougl.; *C. milleri* (Busck) in the Sierra Nevada of California (Struble, 1972), and *C. starki* (Freeman) in the Canadian Rockies (Stark, 1954, 1959). Two other species of *Coleotechnites*, *C. ponderosana* Hodges and Stevens from Colorado (Hodges and Stevens, 1978) and an undescribed species infesting Jeffrey pine, *P. jeffreyi* Grev. and Balf. in southern California (Luck, 1976), have also been studied, but in lesser detail.

DISTRIBUTION

We have reared *C. edulicola* from a number of northern New Mexico localities, and have seen specimens reared from pinyon in southern Utah (Fig. 1). We have also seen evidence of larval activity near Salida, Chaffee County; Pueblo, Pueblo County; Walsenburg, Huerfano County,

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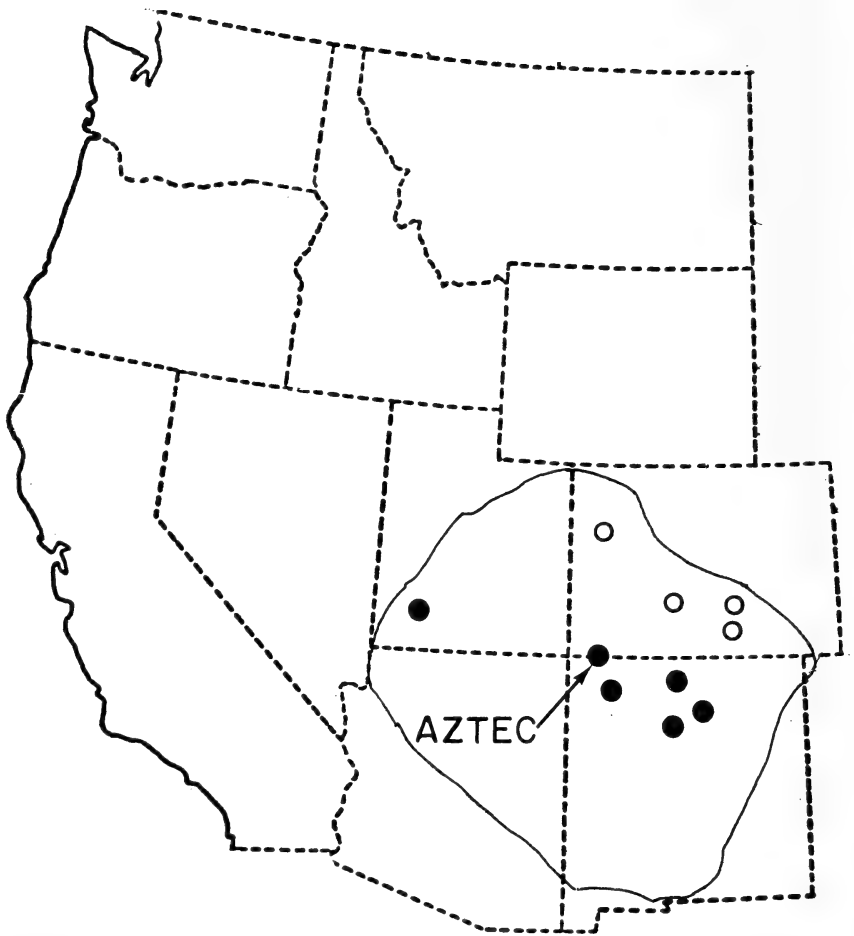


Fig. 1. Occurrence of *Coleotechnites edulicola* within general range of *Pinus edulis*; ●—adults reared, ○—larval feeding observed.

and Rio Blanco, Rio Blanco County, Colorado. The range of *C. edulicola* may in fact coincide with that of pinyon over much of the Southwest. All the rearings and feeding observations have been from naturally occurring trees.

LIFE HISTORY AND HABITS

Coleotechnites edulicola has a 1-year life cycle; the adults fly in early summer and young larvae make up the overwintering stage (Fig. 2).

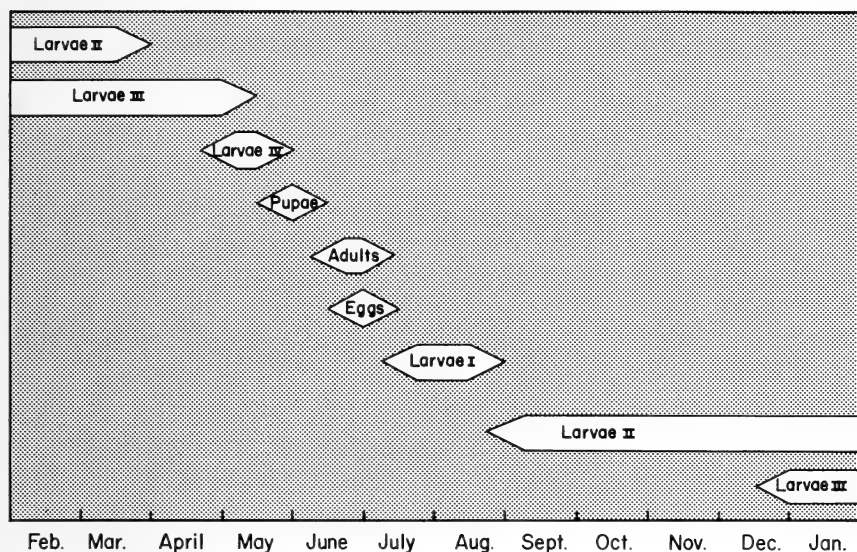


Fig. 2. Generalized life history of *Coleotechnites edulicola* at Aztec, New Mexico.

The following details of the life history were developed from a series of observations, collections, and rearings, mainly of the Aztec population, during the period 1973–1976.

Adults

The adults are small silvery-gray moths, wingspan ca. 10 mm, found from early June through mid-July. Hodges and Stevens (1978) present a detailed description of both sexes. The moths are generally quiescent during the daytime, rendered nearly invisible against twigs and bark by their pattern of black and silver scales. When disturbed they fly rapidly for a few seconds, generally within the branches of the tree on which they were resting, and upon re-aligning, scurry rapidly to another resting spot. Mating and oviposition have not been seen.

Eggs

The eggs are yellow-orange, nearly globular, and ca. 0.2 mm in diameter. They are laid in clusters of variable size, around 6–12 eggs each. Most eggs are laid inside needles mined out the previous year. A few are also found in older mines. The eggs are generally within 1 or 2 mm from an opening—either an exit hole or a “ventilation” hole.

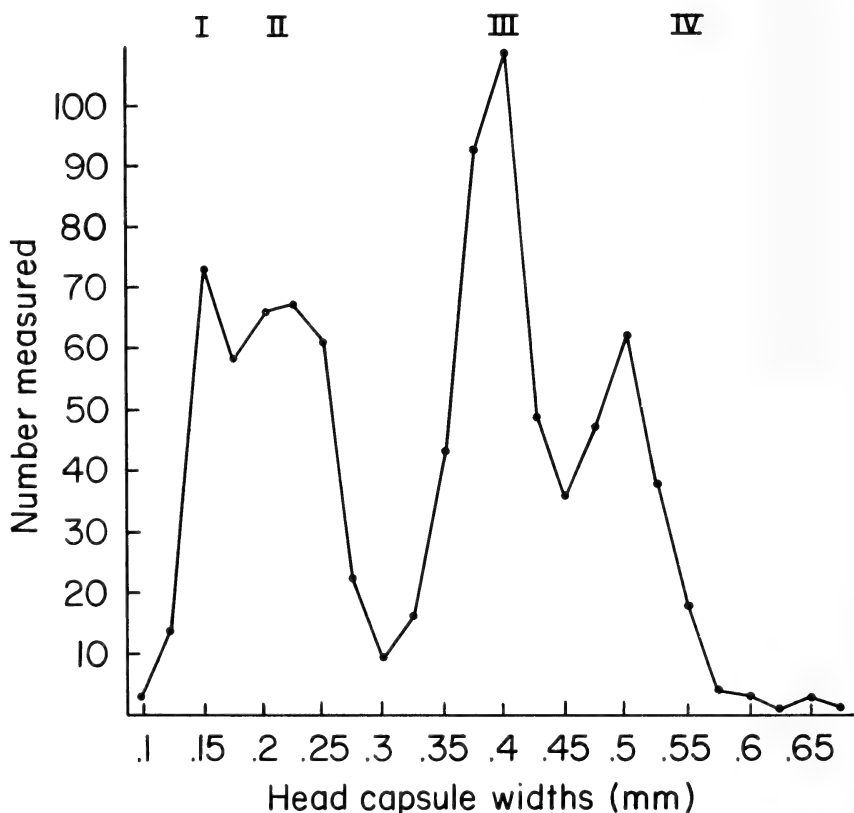


Fig. 3. Head capsule measurements ($n = 894$) of *Coleotechnites edulicola* larvae.

Larvae

The eggs begin hatching around the end of June (Fig. 2) and the stage I larvae crawl to and colonize previously uninfested needles. The larval period lasts most of the year, from early July until May or early June of the following summer. Measurements of 894 head capsules yielded a frequency curve with 4 distinct peaks, indicating 4 instars (Fig. 3). Inspection of the curve might suggest stages I and II larvae are members of the same set; however abandoned stage I head capsules were readily found in mines containing stage II larvae, thus confirming 2 early larval stages with head capsule widths averaging ca. 0.15 and 0.25 mm, respectively. These observations on number of larval stages and head capsule sizes closely parallel those reported by Luck (1976) on the only other univoltine *Coleotechnites* studied in comparable detail.

As shown in Fig. 2, *C. edulicola* was found to overwinter in both instars II and III. Larva II is by far the most protracted stage.

Most (ratio ca. 5:1) larvae are found in needles of the current year's growth; i.e., most needles are attacked the year they are produced. A few larvae infest older needles. Initial entry by stage I caterpillars is made on the convex side of the needle, within ca. 2 mm of the apex. Early in the larval period (e.g. 23 July 1975) mines are visible to the naked eye only on close inspection. No more than a single larva per needle was ever found.

As the larval period continues, additional needles of the current year's growth are invaded. Within the same needle bundle, larvae cross between the flat (facing) needle sides; a small amount of silk often holds the 2 needles temporarily together. Larvae move to other needle bundles without production of silk.

In the early larval period (instar I) frass is packed into the mined-out needle, but in later stages it is pushed out. Needles inhabited by 3d or 4th stage larvae have several holes for frass disposal and larval exit.

Throughout their lives the larvae are medium brown—most are uniformly colored, others tend to be mottled. Head capsules and thoracic and anal shields are dark brown to black. Fully developed larvae are ca. 8 mm long.

Pupae

C. edulicola pupates around the end of May within the last mined needle, near an open hole cut by the larva near the needle apex. The pupae are elongate, cylindrical, black, and about 6 mm long.

EFFECT ON HOST TREES

Repeated defoliation by *Coleotechnites* needle miners reduces growth of stems, shoots, and needles, and—in more severe cases—kills trees (e.g., Struble, 1972). Such appears to be the general case with *C. edulicola*. All degrees of damage, including tree mortality presumably resulting from repeated defoliation, could be found at the Aztec site. Under the circumstances (unmanaged southwestern pinyon-juniper forest), such mortality does not constitute a problem. Only where pinyons are intensively cultured and/or appearance is important would the species likely be considered a pest.

Fig. 4 compares the appearance of shoots on a currently infested, persistently defoliated tree with one that is essentially uninfested. The infested needles are shed prematurely, leaving the shoots with a characteristic bare-stemmed, tufted appearance.



Fig. 4. Branches from adjacent pinyons showing effects of severe (left) and negligible (right) defoliation caused by *Coleotechnites edulicola*.

C. edulicola shares with *C. ponderosana* (Stevens, 1973) the characteristic of colonizing trees in a highly differential manner. For example, the shoots shown in Fig. 4 were taken at the same time from comparable parts of 2 adjacent pinyons. One tree was severely defoliated (29.7% of the needles infested) while infestation was negligible on the other. Tree resistance may be involved.

ASSOCIATES

Several species of parasitic Hymenoptera were dissected or reared from samples of pinyon foliage infested with *C. edulicola* from Aztec, Santa Fe, and Nageezi (San Juan County), New Mexico. These included undetermined species of *Chrysocharis* and *Di cladocerus* and a single specimen of *Zagrammosoma multilineatum* (Ashmead), all Eulophidae, and several pteromalids, not determined beyond family. A possibly undescribed *Apanteles* (Braconidae) was reared abundantly from Aztec.

ACKNOWLEDGMENTS

We thank Les Eklund and Ron Shannon for field assistance. Associated parasitic Hymenoptera were identified by Gordon Gordh (Eulophidae, Pteromalidae) and P. M. Marsh (*Apanteles*), U.S. National Museum, Washington, D. C.

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PIERIS NAPI OLERACEA (PIERIDAE) CAUGHT BY INSECTIVOROUS PLANT

Pieris napi oleracea Harris is frequently found in bog areas (Shull 1977, J. Lepid. Soc. 31: 68-70) and swamps where insectivorous plants may occur. On 20 June 1977, Pamela Matthews, James Douglas, and I were collecting in a white cedar (*Thuja occidentalis* L.) swamp north of Craftsbury, Orleans Co., Vermont. The swamp contains sphagnum moss and small patches of sundew plants (*Drosera rotundifolia* L.). In a sphagnum patch by our trail, we found a dead *P. n. oleracea* female, which was caught by the dorsal surface of its body and wings on several of the sticky sundew leaves. The external cuticle of the hapless butterfly appeared to be intact, but the internal soft parts were gone. Because we had visited this area twice during the previous week, and such a white object near our path would have attracted our attention, we surmise that the butterfly had died recently. How it became caught in the sundew, and whether its internal parts were digested by the plant or by some sucking predator which encountered the immobilized butterfly are not known.

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MEYRICK'S RECORD OF "*MECYNA FURNACALIS*, GN." FROM
FIJI, WITH A NEW GENERIC ASSIGNMENT FOR
PYRAUSTA HOMALOXANTHA MEYRICK
(PYRALIDAE: PYRAUSTINAE)

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ABSTRACT. Meyrick's record of *Mecyna furnacalis* (Guenée) from Fiji belongs not to Guenée's species—described in *Botys* and now placed in *Ostrinia*—but to *Pyrausta homaloxantha* Meyrick, described in 1933 from Fiji. This species is transferred to *Xanthopsamma* Munroe and Mutuura, a genus previously known from three species from Japan, Korea, mainland China and Hainan. Figures of male and female moths and genitalia are given and differential characters are noted. The apparent isolation of the Fijian species may not be significant, as other species are likely to turn up in the Indo-Papuan region.

Meyrick (1886: 264) identified a male and a female moth from Fiji as *Botys furnacalis* Guenée, 1854: 332, and transferred the species to "*Mecyna*, Gn.," saying, "This species agrees well enough with Guenée's description, but as that is in some respects incomplete, I have redescribed it to prevent error. . . . Guenée's type is stated to be from Australia, but I think this is probably an error, and may be neglected until confirmed."

Mr. Michael Shaffer has called our attention to a male specimen from Fiji in the British Museum (Natural History), which for many years was labelled "Type" over the name label "*furnacalis* Meyr." This is evidently the male recorded by Meyrick (1886), as we have been unable to trace any *furnacalis* named by Meyrick. Meyrick's identification, which we overlooked when we referred *Botys furnacalis* Guenée to *Ostrinia* in our revision of that genus (Mutuura and Munroe, 1970: 33), is erroneous. We consider the specimen conspecific with *Pyrausta homaloxantha* Meyrick (1933: 411), described from a female holotype from Vunidawa, Fiji, in the British Museum (Natural History). The maculation is virtually identical in the two specimens (Figs. 1, 2), the localities agree sufficiently, and as will be shown, the genital characters of the two sexes are concordant.

The species is not properly referable to *Pyrausta* Schrank, 1802, (= *Botys* Latreille, 1802-1803), to *Mecyna* Doubleday, 1850, to *Mecyna* in the sense of Guenée, 1854, (= *Uresiphita* Hübner, [1825]) or to *Ostrinia* Hübner, [1825], all of which differs more or less widely in genital characters (see Munroe, 1950, 1976). Instead, the species is



Figs. 1, 2. *Xanthopsamma homaloxantha* (Meyrick), specimens in British Museum (Natural History). 1, ♂, so-called type of "*furnacalis* Meyr."; 2, ♀, holotype of *Pyrausta homaloxantha* Meyrick.



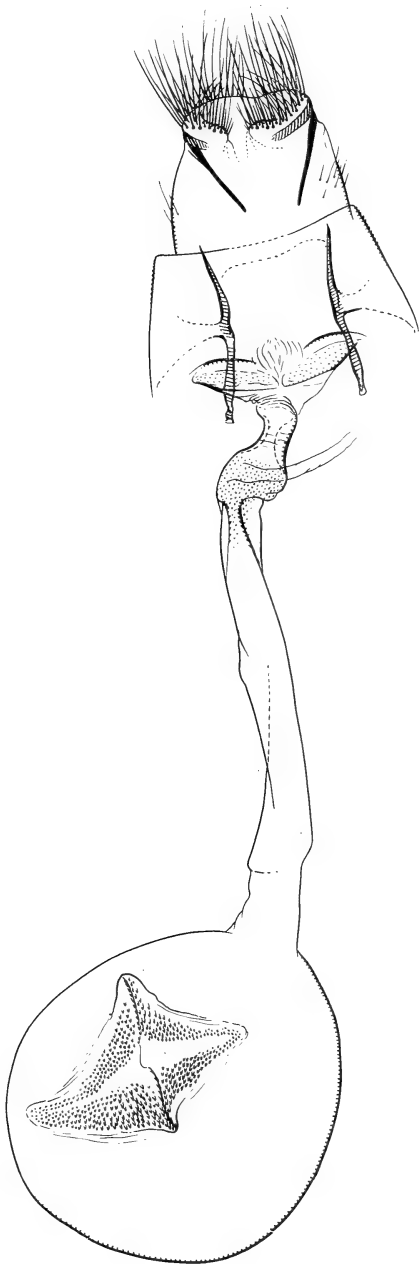
Fig. 3. *Xanthopsamma homaloxantha* (Meyrick), ♂ genitalia of specimen illustrated in Fig. 1.

clearly a member of the genus *Xanthopsamma* Munroe and Mutuura, 1968, previously known from a complex of three species from Japan, Korea, mainland China and Hainan. The Fijian species agrees in external structural characters and in the essentials of male and female genitalia with the type-species, *X. aurantialis* Munroe and Mutuura, 1968, and its previously recognized relatives.

In maculation *X. homaloxantha* (Meyrick), n. comb., differs from its temperate east Asian congeners in its yellower forewing, without terminal infuscation, with finer but more distinct transverse lines, and with relatively weaker discocellular bar, and in the contrastingly whitish-yellow, not almost concolorous buff or fulvous hindwing, without post-medial line or terminal infuscation. The termen of the forewing is less strongly curved than in the previously included species and the wing consequently appears wider and its apex sharper.

The male genitalia (Fig. 3) are closely similar to those of *X. aurantialis* and *X. youboialis*, but have the uncus relatively narrower and sharper, the dorsal prominence of the sacculus longer and more gradually rounded, and the spinulose zone at the base of the basally directed lobe of the clasper somewhat wider. The female genitalia (Fig. 4) resemble those of *X. aurantialis*, but have the tapering part of the ostial chamber shorter and separated from the collar of the *ductus bursae* by a narrow unsclerotized zone, and have the signum relatively larger.

At present no great significance should be attached to the apparent wide disjunction in the geographical range of the genus, as further species may well exist in tropical Asia and Melanesia.



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Fig. 4. *Xanthopsamma homaloxantha* (Meyrick), ♀ genitalia of holotype (see Fig. 2).

ACKNOWLEDGMENTS

We thank Mr. Michael Shaffer and the authorities of the British Museum (Natural History) for information and the opportunity to study the material discussed. The photograph of male genitalia was made by Mr. T. Stovell, Graphics Unit, Agriculture Canada, with the assistance of Mr. D. H. Kritsch. The drawing of female genitalia was made by Mr. Arthur Smith.

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SCREECH OWL PREYS ON *PERIDOMA PLECTA* (NOCTUIDAE)

As part of a long term study of populations and mortality of the Screech Owl (*Otus asio*) I collected a vehicle killed specimen near Oxford, Connecticut on 4 May 1976. Routine measurements were taken and stomach contents analyzed. Eight larvae of the Flame-shouldered Dart, *Peridroma plecta* L. (Noctuidae) were found among the owl's stomach contents. The *P. plecta* larvae were fresh and readily identifiable, suggesting that the owl was killed shortly after feeding, but before digestion had begun. Although Bent (1938, U.S. Nat. Hist. Mus. Bull. 168. 482 p.) and others have recorded a variety of Lepidopteran adults and larvae as occasional Screech Owl prey, this constitutes the first record of such for noctuid species. This observation indicates the susceptibility of noctuid larvae to efficient nocturnal predators. It also provides absolute evidence that at least one species of large, avian raptor will feed opportunistically on available insect larvae.

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"ORANGE" BANDS, A SIMPLE RECESSIVE IN *ANARTIA FATIMA* (NYMPHALIDAE)

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ABSTRACT. Breeding experiments with aberrant *Anartia fatima* butterflies having orange instead of red hindwing markings produced results consistent with the interpretation that the orange color is due to the homozygous condition of a simple Mendelian recessive allele.

We report here on the genetics of a color aberration in the common Central American nymphalid butterfly *Anartia fatima* Fab. Throughout its range, from southern Texas south into eastern Panama, *A. fatima* bears on the hindwings a conspicuous, elongate red band, approximately 9 mm long by 2 mm wide (Fig. 1, arrow). Wing pattern is identical in males and females, and it is usually necessary to examine the genitalia in order to distinguish the sexes.

Butterflies in which the hindwing markings are orange instead of red (Fig. 1, right) appeared among the progeny of a phenotypically "red" female from Achiote, Colon Province, Panama. This individual had been brought to Barro Colorado Island in the Canal Zone during June 1977 as part of a larger study involving the rearing of many *A. fatima* for behavior and genetic research. Among her 91 offspring, 21 had orange bands, a ratio of 3.33:1, "red": "orange" butterflies.

Using these offspring, we obtained the crosses shown in Table 1. "Orange" bred true. Two "red" to "red" crosses produced entirely "red" individuals, while one other "red" to "red" cross produced a ratio of 3.53:1 "red": "orange" individuals. Three "orange" to "red" crosses produced 44 "red" butterflies, with no "orange" appearing.

These results are consistent with the interpretation that a simple Mendelian recessive allele (*r*) is involved, with a double dose (*rr*) resulting in the "orange" phenotype. The "red" female from Achiote must have been heterozygous for "orange" (*Rr*) and so must have been her mate. The same would be true of the two "red" pairs which produced the 15 "orange" out of 68 offspring.

A. M. Shapiro (pers. comm.) has seen an orange variant in *A. amathea* at Cali, Colombia. Considering both the partial genetic intercompatibility of *A. fatima* and *A. amathea* (Silberglied and Aiello, in prep.) and the intermediate expression of red pigmentation among hybrids,

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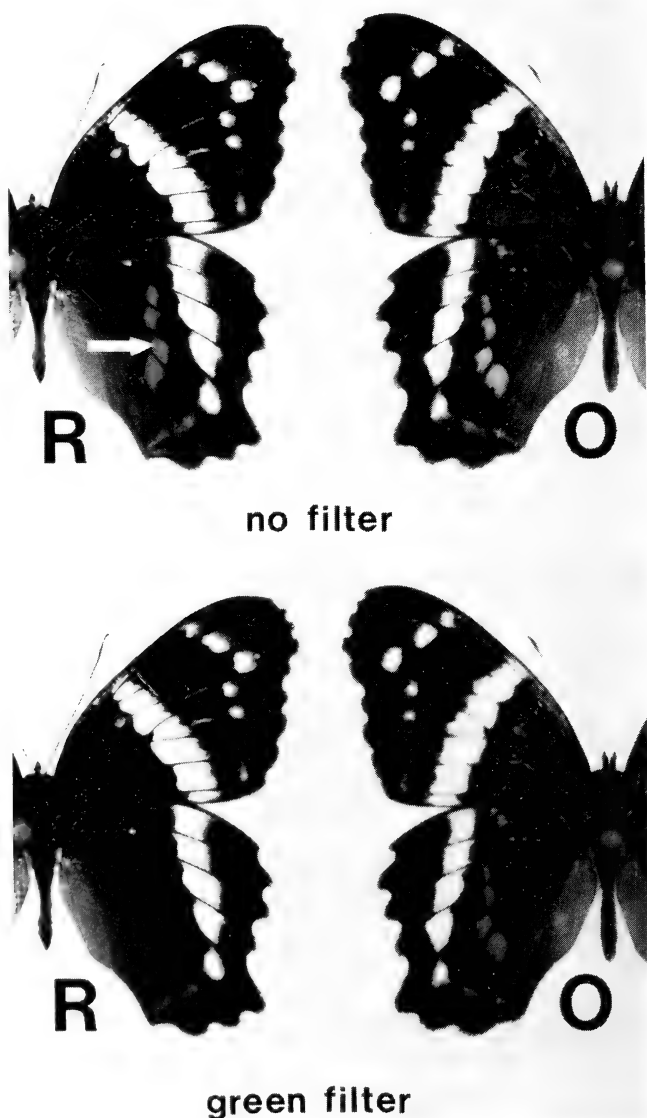


Fig. 1. "Red" (wild type, left) and "orange" (aberration, right) phenotypes of *A. fatima* (males). The arrow (upper left) indicates the characteristic colored band. The lower photographs were taken through a green filter (Tiffen green no. 1) to enhance the contrast between the bands of the two phenotypes.

TABLE 1. Crosses involving the "orange" phenotype of *Anartia fatima*.

Phenotypes ¹ of parents		Number of crosses	Phenotypes of progeny		Expected ratio, R:O, if a simple recessive	p ²
♀	♂		"red"	"orange"		
R ³	♀ ⁴	1	70	21	3:1	>.5
R ⁵	R ⁵	1	53	15	3:1	>.5
R ⁵	R	2	38	0	1:0	-
O ⁵	R	3	44	0	1:0	-
O ⁵	O ⁵	1	0	78	0:1	-

¹ R = "red," O = "orange."² Probability (Chi-square test, 1 degree of freedom) that differences between expected and observed values are due to chance alone.³ Female collected in Achiote, Panama.⁴ Phenotype of male unknown; presumed (based upon results) to be "red" (and genotype presumed to be Rr).⁵ Progeny of female collected in Achiote, Panama.

that variant is likely to be genetically homologous with the one reported here.

Specimens of this aberration have been deposited in the collections of the Museum of Comparative Zoology, Harvard University; Peabody Museum of Natural History, Yale University; American Museum of Natural History, New York; National Museum of Natural History, Washington, D.C.; and G. B. Small, Panama Canal Zone.

A GYNANDROMORPH OF *PAPILIO POLYXENES* (PAPILIONIDAE)

Cultures of *Papilio polyxenes asterius* Stoll are maintained in our laboratory for use in ecological studies. In October 1975, a bilateral gynandromorph of this species appeared in the second generation of a laboratory culture derived from populations around Brooktondale, Tompkins County, New York. This was the first such specimen observed.

Although the external genitalia are male, only the right half of the specimen is male in appearance (Fig. 1). The yellow spots of the inner row of the right forewing



Fig. 1. Lab-reared gynandromorph of *Papilio polyxenes*, dorsal view.

are greatly reduced and/or appear as "ghosts" composed of scales intermediate in color between black and yellow. The inner band of the hind wing resembles a normal male except for the last yellow spot (Cu_1 cell) which is half obliterated by black scales. The hazy blue spots of the hind wing are irregular and appear in cells Cu_1 , Cu_2 , M_2 , and M_3 . The left half of the specimen perfectly resembles a female. The left forewing is 43 mm in length, the right is 41 mm.

Instances of gynandromorphism among the swallowtails are rare. Schmid (1973, Can. Entomol. 105: 1549-1551) describes natural gynandromorphs of *Ornithoptera victoriae* Gray and *O. priamus* L. Skinner (1919, Entomol. News 30: 247) and Cockayne (1935, Trans. Roy. Entomol. Soc. Lond. 83: 509-522) refer to *Papilio glaucus* L. gynandromorphs. Hybrid crosses between *P. polyxenes* and other swallowtails in the *machaon* group have in some cases yielded gynandromorphic individuals (Clark and Sheppard, 1953, Suppl. Entomol. Rec. 65: 1-12; Ae 1964, Bull. Jap. Entomol. Acad. 1: 1-10). Edwards (1868-1872, The Butterflies of North America; Philadelphia:

Am. Entomol. Soc.) presents a figure of an apparently gynandromorphic *P. polyxenes*, but offers no data on the specimen.

It is not known what caused the butterfly described here to be a gynandromorph. Gardiner (1972, J. Res. Lep. 11: 129-140) notes that the incidence of gynandromorphism in *Pieris brassicae* L. cultures is associated with outbreaks of virus and suggests that viral disease may cause such genetic abnormalities. Viral disease is commonly present at low levels in our cultures of *P. polyxenes* and may account for the appearance of this unusual individual.

The specimen is located in Lot 1062 of the Entomological Collections at Cornell University. I wish to acknowledge the support of N.S.F. Grant DEB 76-20114 (to Paul P. Feeny) which covered costs of publication.

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Journal of the Lepidopterists' Society
32(2), 1978, 139-140

ELECTROSTRYMON ANGELIA ANGELIA (LYCAENIDAE): THE OLDEST FLORIDA RECORD?

The butterflies, SpHINGIDAE and Castniidae from the Strecker collection were transferred from the Field Museum of Natural History to this institution in 1976 on semi-permanent loan in order that they might be more readily utilized by students of these groups. Since that time workers here and elsewhere have made greater use of the Strecker and Reakirt material contained in Strecker's collection.

That collection is, however, an aggravating one by modern standards: there are few labels on individual specimens; rather, the series are labelled with data that in theory apply to all members under the label. This is certainly not the case in all instances. Fortunately, Strecker prepared catalogs to the Papilionidae, Pieridae and Lycaenidae before his death, and in these families the data for individual specimens are recorded.

A second problem involves Strecker's apparently too-eager interpretation of what specimen was what, and from where. Some of the putative Reakirt types in the collection may not be those, and we suspect that Strecker was easy prey for dealers who peddled material mislabelled by locality. The situation with the Strecker collection is by no means as bad as that with some other older collections, notably the Ehrmann collection presently housed at Carnegie Museum of Natural History.

Nevertheless, the Strecker collection contains some magnificent material—material that is not duplicated in other North American collections. Further, the Strecker collection, with its associated letters, is an historical document. The Lycaenidae, because that family was one for which the catalog was completed, are especially interesting. In working through the hairstreaks in the Strecker collection, specimens of *Electrostrymon angelia* (Hewitson) were found under the label "*Thecla hugon* Godart", a synonym of *Electrostrymon endymion* (Fabricius). Two of these specimens were placed in the collection after Strecker had compiled the catalog and are individually labelled "Haiti" and "Port au Prince, Haiti"; both of these butterflies are specimens of the Hispaniolan subspecies *boyeri* (W. P. Comstock and Huntington). The other specimen is labelled characteristically with an "a", referring to an entry in the catalog. This specimen is here figured (Fig. 1) and is referable to the Cuban *E. a. angelia*. The catalog states that the specimen was from "Florida" and that

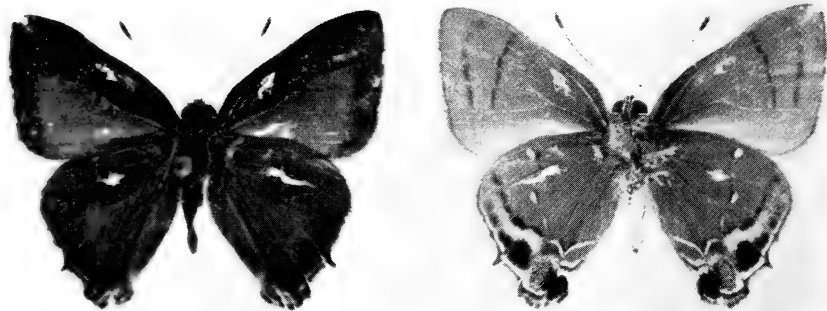


Fig. 1. *Electrostrymon angelia angelia* (Hewitson), ♂ upper (left) and under (right) surfaces; FLORIDA, Chas. Dury (Strecker collection). Allyn Museum photos 071477-15/16.

Strecker received it from Charles Dury. No date is given, but it is likely that the specimen was taken before 1880.

Kimball (1965, *Lepidoptera of Florida*) does not list Dury among the pioneer Florida collectors, and it is possible that while Strecker received the *angelia* from Dury, Dury himself may not have collected it. Were it not for the fact that Anderson (1974, *J. Lepid. Soc.*, 28: 354-358) had recorded this species from the Florida Keys, and others have reported it from as far north as the Fort Lauderdale area on the east coast of the state, it would be tempting to dismiss the Strecker specimen as a hoax or a mislabelled specimen. I suspect, though, that the Dury/Strecker specimen is an authentic one, and quite possibly *angelia* long has been a member of the Florida fauna, though perhaps not so commonly as in the past few years.

It is further likely that specimens of *angelia* may have been responsible for the long-standing records of *E. endymion* from Florida. The specimen that Holland (1931, *The Butterfly Book*: pl. 64, Fig. 32) figured as "*endymion*" was actually a specimen of *E. angelia boyeri* (Klots, 1951, *Field Guide to the Butterflies . . .*: 281), and the latter author expressed doubt about the occurrence of *endymion* in Florida. Riley (1975, *Field Guide . . . Butterflies of the West Indies*) does not mention *endymion* from the West Indies, thus strongly suggesting that the species never has occurred in Florida.

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OBSERVATIONS ON *ERORA LAETA* (LYCAENIDAE) IN NEW HAMPSHIRE

Erora laeta Edwards, often considered the rarest of eastern butterflies, is eagerly sought by many lepidopterists; too often with negative results. I made my first trip to New Hampshire to capture this species on 21 May, 1977 with fellow collector Reginald Webster. We visited a few areas in Carroll County, near Bartlett, in northern New Hampshire, where R. W. had taken one specimen the previous year.

The location seemed typical for *laeta*—an abandoned dirt road going through a beech woods.

We hiked up the road until we reached a shallow gulley crossing the road. On the other side of the gulley, on damp dirt, was a female *E. laeta*, which was quickly netted. We then saw another female which was also easily caught. At this point, I was amazed, for we had hoped to find one or two *E. laeta* in a day of intense collecting, and had caught two in 10 minutes. Continuing along the road, we came to a little trickle of a stream where we caught two more *laeta*, both females. Upon returning to the first gulley, we caught three more females.

Astounded by our luck we decided to try a few more dirt roads in the area. On every one, we found *laeta*. It was incredible; was this really that rarest of butterflies that we were seeing everywhere we looked? In about three hours of collecting we must have seen over 80 *E. laeta*, and had collected one or two from every road we tried, ending up with about 12 specimens apiece. When these numbers are compared to those reported in previous literature (e.g., Mousley, 1923, *The Can. Entomol.* 55: 26–29; Field, 1941, *Ann. Entomol. Soc. of America* 34: 303–316; Smith, 1960, *J. Lepid. Soc.* 14: 239–240; Roever, 1962, *J. Lepid. Soc.* 16: 1–4), our sightings seem truly phenomenal. The most specimens previously reported collected at one time were two males and nine females along the slopes of Mount Killington in New Hampshire (Field, op. cit.), and many reports are of individual specimens taken by chance (e.g., Sullivan, 1971, *J. Lepid. Soc.* 25: 295–296).

Of all the individuals that we saw, only two were males, only one of which was captured. Among the females, some were quite worn, while others looked freshly emerged. There seem two likely reasons, not necessarily mutually exclusive, for the dearth of males: 1) the males had emerged earlier in the season and so most had already died, and 2) the males remained up in the trees, and only females came down to drink at the mud. However the male that was caught was freshly emerged, and in most species of butterflies, it is the males that are found “puddling” (Downes, 1973, *J. Lepid. Soc.* 27: 89–99). The single male was caught in a field next to the woods.

The females were very easy to catch, some not even flying up when the net was clapped over them. This behavior has been noted by previous authors (e.g., Hessel, 1952, *J. Lepid. Soc.* 6:34), but strongly impressed me when I nearly stepped on one female as I was walking down the road; it flew up from right under my foot. The males, on the other hand, were more restless and difficult to catch, their flight being fast and uneven, with only occasional landings on vegetation.

Two possible explanations for the extraordinary abundance of *E. laeta* that we observed are as follows: It is possible that there was a real population explosion of *E. laeta* in New Hampshire in 1977 (W. Kiel, who has collected for years in New Hampshire, caught his first *E. laeta* this spring). It would be interesting to know if other lepidopterists found a similar increase in this species in other areas. An alternative explanation is that *laeta* is really not that rare, but that its behavior on this day was unusual. Perhaps the butterflies normally spend most of their time in the forest canopy, and thus are not accessible to collectors. This day being very sunny, hot (33°C), and humid, perhaps drove them down to the ground to drink. It may be that early emergence and a short flight period make *E. laeta* seem very rare, but that finding them is really a matter of being in the right place at the right time. At any rate, we were!

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OBITUARY



WILBUR S. McALPINE (1888-1977)

Mr. Wilbur S. McAlpine, charter member of The Lepidopterists' Society, passed away on 30 July 1977, at the Grovecrest Convalescent Home in Pontiac, Michigan, at the age of 88. 'Mac,' as he was known by many of his friends, deeply enjoyed nature and the out-of-doors, and was a devoted amateur lepidopterist, spending most of his spare time collecting and studying Michigan moths and butterflies. He was particularly interested in the life history of many local Oakland County species and specialized in the genus *Calephelis*, the metalmark butterflies.

Wilbur was born in Detroit, Michigan, on 30 December 1888, and graduated from Detroit Central High School in January, 1908. He held positions as a draftsman with the U.S. Lake Survey, Michigan Central Railroad, and Detroit Edison, and was also employed as an Assistant Surveyor of Coal Claims in Homer, Alaska during 1906, 1907, 1911 and 1912. He served with the military in the 472nd Engineers during the First World War in 1918. Wilbur became the principal and owner of a mapping, surveying and engineering business under the names of McAlpine Engineers, Inc. and W. S. McAlpine Map Co. from December, 1915, until his retirement in 1965, when he sold his business to the employees. They are still conducting the business under the same names.

While operating his business, the firm produced complete maps of all Michigan counties, especially detailed maps of Oakland County. McAlpine published an Atlas of Oakland County, and engineered and recorded over two hundred subdivision plats and made numerous farm, residential lot and topographic surveys, which are still in use today. Undoubtedly, many of the Oakland County lepidoptera collected by McAlpine were discovered during his surveying activities. He witnessed the disappearance of many of his favorite collecting sites due to the suburban encroachment moving outward from Detroit.

McAlpine will always be remembered by mid-western lepidopterists as the one who described the Swamp Metalmark, *C. muticum*, and subsequently worked out its life history. In 1971, he culminated his intense interest in the *Calephelis* with his publication on the revision of the genus, describing 25 new species and 7 new subspecies

mostly from Mexico and Central America. McAlpine also worked out the life history of several other Michigan species, including *Hyalophora columbia* (Smith), *Callophrys* and *Hesperiidae* species, which unfortunately were never published. He was one of the first to locate several *H. columbia* tamarack bogs in southeastern Michigan, and eventually secured numerous cocoons and reared many in his backyard cages. McAlpine was a very determined Michigan butterfly collector who would travel anywhere, anytime to add a new species to his collection. Unfortunately, the many years devoted to his *Calephelis* project left him with little time for his personal collection and other lepidopteral plans and pursuits. One of his plans that failed to materialize due to his death was the publication of a guidebook of Michigan butterflies, complete with colored plates of all known species found in the state. This project was a lifelong ambition to stimulate appreciation for and further the knowledge of Michigan butterflies, especially among young people. Two of his friends of long standing, Dr. George W. Rawson and John H. Newman, and this writer to serve as editor, were to collaborate with 'Mac'. Although this project is still continuing, the extremely high cost of colored plates has made it necessary to re-adjust the original goal.

In 1972, McAlpine donated the bulk of his collection, over 12,000 specimens, including many *Calephelis* type specimens, to the Smithsonian Institution. Later, he also donated approximately 800 moths and butterflies and 700 miscellaneous insects to the collection at Michigan State University at East Lansing, and a lesser amount to The University of Michigan at Ann Arbor. His collection, rich in Michigan material, included a long series of *H. columbia* and its *cecropia* hybrid, *Colias interior* (Scudder) and *Oeneis chryxus strigulosa* (McDunnough), and miscellaneous Alaskan lepidoptera and other insects.

McAlpine was an Honorary Member of The Michigan Entomological Society and held memberships in the former Detroit Entomological Society, The Entomological Society of Canada and The Lepidoptera Research Foundation, Inc. He was affiliated with the Cranbrook Institute of Science in Bloomfield Hills, and was made a Life Member of The Michigan Society of Registered Land Surveyors on 11 February 1970. He travelled widely in the United States and Mexico and examined museum collections and collected *Calephelis* material; and also visited the British and Paris museums in connection with his metalmark studies.

In addition to his interest in lepidoptera, 'Mac' was a devoted and active churchman. He particularly enjoyed evangelistic singing as a soloist, and sang in the choir at the First Baptist Church of Birmingham. He and his late wife, the former Minnie Burnett, are survived by one son, Wilbur Burnett, plus 16 nieces and nephews. Mrs. McAlpine died in January, 1975.

I wish to express my appreciation to Wilbur's brother-in-law, Mr. Percy C. Burnett of Pontiac, and his minister, Dr. Glenn H. Asquith, Jr. for information in preparing this manuscript.

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BOOK REVIEW

FREDERICK WILLIAM FROHAWK, by Valezina Bolingbroke, 1977. E. W. Classey Ltd. Park Rd. Faringdon, Oxon., England. 16 p., 3 figures (photographs), cover drawing in color by F.W.F.

“... I am going to attempt to give just a brief ‘impression’ of him,” writes the author on page 1 of this little memoir. The author is not an artist nor a writer as was Mr. Frohawk, nor a fellow naturalist, but his own daughter. It is obvious from the start that she felt for him the love and admiration which any father hopes to inspire in his daughter. The narrative is a series of glimpses into the past, rather like impressionist paintings seen from a distance, as Ms. Bolingbroke rambles through the English countryside with her readers. One sees an ancient house with moat and drawbridge, a little stone village, an old fashioned garden, a field of cowslips, travellers in a ‘pony trap’—all interspersed with charming and humorous incidents, flashes into the character of her father, his colleagues, his accomplishments and his deep love for all of nature, from a very small butterfly to a very young human being. Frohawk was both author and illustrator of distinguished books on Ornithology and Lepidoptero-logy, but his vast knowledge encompassed many other aspects of nature including wild flowers, reptiles and weather patterns, to name but a few. One is left wanting to know much more than this ‘brief impression’ gives us of F.W.F., as Frohawk was affectionately nicknamed by his friends.

JO BREWER, *Editor, The News of the Lepidopterists' Society, 257 Common St., Dedham, MA 02026.*

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Text: Manuscripts should be submitted in *duplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, $8\frac{1}{2} \times 11$ inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard, 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

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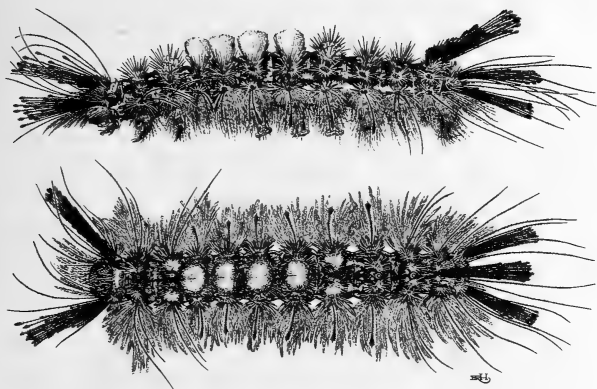
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Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

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Cover illustration: *Dasychira dorsipennata* larva, dorsal and lateral views. From Fascicle 22.2, "Lymantriidae," by Douglas C. Ferguson, in *Moths of America North of Mexico*. The drawing was done by E. R. Hodges, Scientific Illustrator, Department of Entomology, Smithsonian Institution. (Reproduced by permission of the author.)

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 32

1978

Number 3

Journal of the Lepidopterists' Society
32(3), 1978, 145-159

THE INFLUENCE OF ENVIRONMENTAL FACTORS ON ROOSTING IN THE BLACK SWALLOWTAIL, *PAPILIO* *POLYXENES ASTERIUS* STOLL (PAPILIONIDAE)

JOHN EDWARD RAWLINS¹ AND ROBERT C. LEDERHOUSE²

ABSTRACT. Black swallowtails, *Papilio polyxenes asterius* Stoll, roost singly in west sloping old-fields in central New York. A frenetic search flight, triggered by decreasing radiation regardless of temperature, precedes roosting. Search flights allow swallowtails to check the suitability of various roosts. Roosts selected favor dorsal basking for as long as possible under decreasing solar radiation. Dorsal basking on the roost ceases, and a roosting posture is assumed when a body temperature high enough for flight can no longer be maintained. Selection for efficient roosting is strong since most adult deaths apparently occur when individuals are roosting. Selection for mimetic or cryptic wing patterns is expected to influence the exposed undersurface of the hindwing more strongly than other wing surfaces hidden during roosting.

Butterflies are active during daylight hours when ambient conditions of radiation and temperature are high enough to allow behavioral maintenance of body temperatures suitable for flight (Vielmetter, 1958; Watt, 1968; Heinrich, 1972). As radiation and ambient temperature fall during the evening, butterflies seek night roosts where they remain until the next morning. Some species roost in aggregations (Crane, 1957; Urquhart, 1960; Benson and Emmel, 1973; Larsen, 1973; Muyschondt and Muyschondt, 1974; Turner, 1975; Young and Thomason, 1975), but most roost singly.

Little is known of roosting behavior in most butterflies in spite of the widely read query concerning roosts in the introduction to Klots' (1951:7) popular field guide. The popular literature is full of comments about butterflies disappearing into trees and fields during evening hours but no detailed study has ever been reported for a species which roosts singly.

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Many butterflies bask in the sun as long as possible in the evening, often on the actual perch that will be used as the night roost. Such behavior has been termed "vesper warming" by Clench (1966). Basking on the roost has been recorded in the hesperiids *Thymelicus lineola* Ochsenheimer and *Ancyloxypha numitor* Fabricius, the lycaenids *Everes comyntas* Godart and *Lycaena phlaeas* L., and the nymphaline *Phyciodes tharos* Drury (Clench, 1966). Powell (1968) records similar behavior for *Incisalia iroides* (Boisduval) (Lycaenidae).

Several authors have suggested that some species choose roosts which are shaded in the setting sun and therefore illuminated by the rising sun earlier the following morning (MacNeill, 1964; Clench, 1966). Such behavior would favor earlier warming by basking the following morning and could conceivably lengthen the period of diurnal activity. Roosting in shadows cast by the setting sun has been observed in *Hesperia* spp. (MacNeill, 1964) and in the satyrines *Euptychia rubricata* Edwards and *Cercyonis meadii* Edwards (Clench, 1966). MacNeill described roosting *Hesperia* as flying directly away from the sun and roosting on the eastern side of bushes. Clench noted the movements of a *Speyeria aphrodite* F. (Nymphalidae). By lining a tree up with the setting sun and then flying directly toward the sun, the butterfly arrived at the shaded side of the intervening tree. After repeating this behavior three or four times, it flew off and roosted in a field. It remains unclear if such shade seeking during roosting is widespread among butterflies, let alone the mechanism by which this is accomplished.

The environmental cues which release roosting behavior have been inadequately studied. When ambient radiation and temperature are low enough to prevent maintenance of a body temperature suitable for flight in the nymphalid *Argynnis paphia* (L.), roosting results (Vielmetter, 1958). This does not explain the onset of roosting on warm evenings when ambient temperatures allow sustained and active flight in the absence of direct insolation. Larsen (1973) has suggested that the timing of roosting events may depend more on decreasing radiation from the setting sun than on decreasing ambient temperature.

From the preceding it seems that selection of the roost site in a given species may involve one of three different roosting patterns: 1) Roosting in shadows cast by the setting sun, therefore hastening exposure to the rising sun the following morning, 2) roosting and basking in areas having maximal exposure to the setting sun, thereby prolonging the period when body temperatures suitable for flight may be maintained, or 3) roosting in areas not related to the position of the sun.

The following study examines in detail the roosting behavior of the

black swallowtail, *Papilio polyxenes asterius* Stoll, and determines what environmental cues direct such behavior. It constitutes the first study of roosting in papilionids [see observations of Gibson and Panchen (1975) on the African *Papilio demodocus* Esper] and the first detailed study of non-gregarious roosting for any butterfly.

MATERIALS AND METHODS

The black or parsnip swallowtail, *Papilio p. asterius* is frequently seen in open clearings and fields throughout eastern North America. The territorial males may be observed for lengthy periods in relatively small areas (Lederhouse, 1978). The darker females are more transient, usually observed flying quickly across these open areas.

Roosting was studied in an old field near Brooktondale, southeast of Ithaca, Tompkins County, New York during the summer of 1975 (Fig. 3). This field was bounded on the north and east by corn fields and on the south and west by dense woody growth. The field was divided into a grid consisting of 276 squares each 10 meters on a side. The relative elevation of each corner of every grid square was established by surveying. Slopes and aspects (compass headings) for every grid square were determined by treating each square as a planar surface with corner elevations most nearly matching those measured. Plant densities for each square were measured by direct count for large, conspicuous species or by counting within a randomly placed 0.5 m² circle for smaller and more numerous species. Only the most abundant plant species are treated in this study. Plant nomenclature follows Fernald (1950).

During each study period, gross solar radiation and ambient temperature were recorded using a centrally-located radiometer and hygrothermograph. Sunset times were established by reference to published readings of the U.S. Naval Observatory for Binghamton, New York (U.S. Printing Office, 1959).

Observations of individual behavior were made by persistently following one swallowtail during the evening hours until it selected a roost. This was difficult due to the rapid and erratic flight of individuals seeking roosts; more often than not the butterfly was lost from sight. Additional data were obtained by systematically walking over the entire grid during dusk noting the location and microhabitat of individuals already on roosts. Observations of behavior during the middle of the day were taken from concurrent research by one of us (J. E. R.) and used for comparative purposes.

Clock times (EDT) were recorded at the onset of flights preceding roosting. Times were also recorded when butterflies were seen to assume

TABLE 1. Behavioral responses and ambient environmental factors associated with roosting in *Papilio polyxenes* compared with values for those variables associated with other diurnal activity.

	Roosting	Non-roosting
	$\bar{x} \pm \text{S.D. (N)}$	$\bar{x} \pm \text{S.D. (N)}$
Flight duration** (seconds)	96 \pm 111 (19)	33 \pm 52 (651)
Perch duration (seconds)	(Overnight)	132 \pm 208 (807)
Perch height* (cm)	53 \pm 18 (36)	64 \pm 27 (794)
Air temperature 150 cm above the ground when roost posture assumed** (Centigrade)	23.9 \pm 3.6 (50)	27.3 \pm 2.7 (801)
Relative humidity when roost posture assumed** (%)	76 \pm 16 (37)	58 \pm 11 (640)
Solar radiation when roost posture assumed** (cal/cm ² /min)	.16 \pm .20 (15)	.85 \pm .15 (254)

Asterisks indicate significance level of two-tailed Student's t-test for differences between roosting and non-roosting mean values: * (.05 > P > .01); ** (P < .01).

a roosting posture with folded wings or when they were discovered already in this posture. Identification of individuals at a distance was made possible by marking the marginal and submarginal row of wing spots with felt-tip pens (Lederhouse, 1978).

RESULTS

Roosting Search Flight

Roosting was always preceded by an extremely rapid and erratic flight of longer average duration than flights at other times of the day (Table 1). The shift from non-roosting activity into this search flight was not gradual but occurred abruptly, the individuals accelerating and often disappearing from sight in seconds. In the 8 cases where a single butterfly was observed throughout a search flight, movement was seen to be circular, the butterfly flying in circles often more than 5 m above the ground. During these flights, which avoided shaded areas, individuals often returned to certain spots in the field, flying low and dipping down into the vegetation.

Search flights were repeatedly interrupted by short periods of perching, lasting one or two seconds. These were on potential roosts which either were not stable in the wind, were deflected greatly by the butterfly's weight, did not provide a good gripping surface (smooth grass culms), were very far from the ground, or were in the deep shade. Butterflies did not select the roost directly but only remained on those perches which were suitable after abandoning many perches which were not.

Behavior on the Roost

Eventually a suitable roost was located and the butterfly positioned itself so that the frontal plane of its body was perpendicular to the incident radiation from the setting sun, spread its wings, raised its abdomen between the spread anal margins of the hindwings, and then remained motionless (Fig. 1). This basking continued for several minutes, being longer on warm evenings than on cool or hazy ones.

Basking ceased if the butterfly came under the advancing shadows of the surrounding vegetation. At the end of basking the abdomen was suddenly lowered, the wings dorsally appressed and swept back such that the hindwings almost totally covered the front wings, and the body brought parallel with the stem or head of the roost plant (Fig. 2). The posture was maintained throughout the night.

The following morning, basking occurred as soon as direct sun fell on the roost. Morning basking appeared identical to that occurring in the evening. Butterflies were seen to rotate about the roost so as to be perpendicular to the rising sun. Morning basking was never seen earlier than two hours after sunrise and usually occurred between 0800 and 0900 (EDT) in July and early August.

Effects of Ambient Temperature and Radiation on Roosting

Mean values of ambient temperature, relative humidity, and solar radiation all differed between roosting and non-roosting situations (Table 1). It was not surprising that the evening hours associated with roosting had significantly lower radiation, lower temperature, and higher relative humidity than earlier in the day.

Papilio polyxenes males are incapable of sustained flight with thoracic temperatures below 24 C (Rawlins, unpublished). This value matches that of the average air temperature when the roost posture with folded wings was observed in the evening (23.9 C). Since radiation was very low at these times, body temperatures would rapidly approach ambient levels in quiescent individuals. Several times individuals which had been roosting less than one minute following vigorous flight were observed to be incapable of sustained flight if disturbed. For example, one female disturbed under .09 cal/cm²/min radiation and 23.3 C ambient temperature was unable to remain airborne and crashed into the grass after a gliding flight of about 5 m. This suggests that the roost posture is assumed under decreasing radiation when ambient temperatures drop below the range of body temperatures allowing activity.

The onset of roost search flight during July and August paralleled the time of meteorological sunset (Fig. 7). This suggests that the onset of

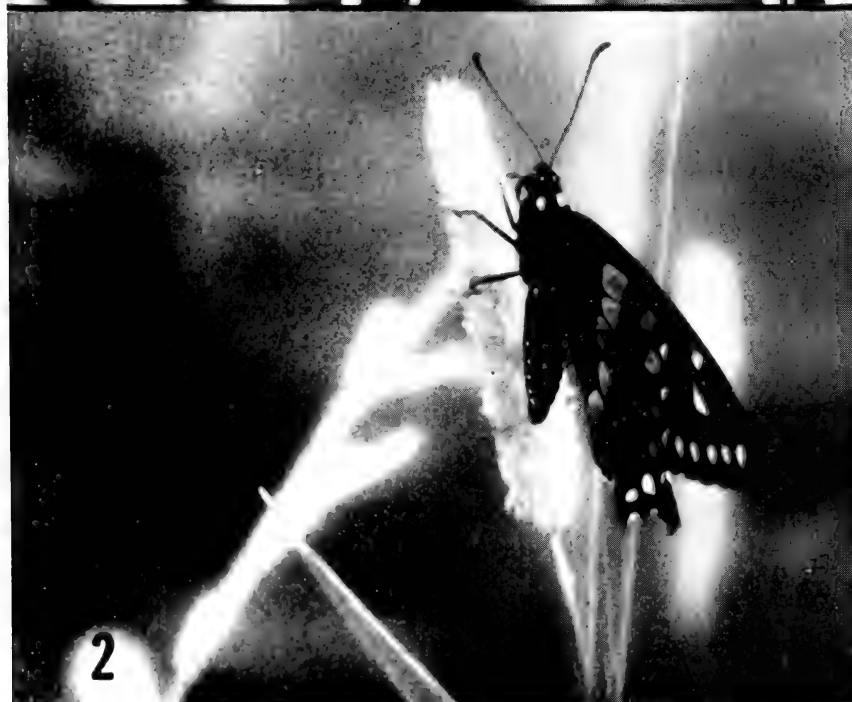


TABLE 2. Plant species used as roosts by *Papilio polyxenes*.

Roost species	Number on heads or apices	Number on stems or culms	Total
<i>Tragopogon pratensis</i> L.*	4	1	5
<i>Lonicera morrowi</i> Gray	0	1	1
<i>Potentilla recta</i> L.*	1	0	1
<i>Solidago altissima</i> L.	0	2	2
<i>Linaria vulgaris</i> Hill	0	1	1
Total dicotyledons	5	5	10
<i>Dactylis glomerata</i> L.	2	0	2
<i>Phleum pratense</i> L.	12	4	16
Other grasses	2	7	9
Total grasses	16	11	27
Total roosts	21	16	37
Percent of total	57%	43%	100%

* All roosts were on dead, leafless scapes of the previous season.

the search flight is cued by decreasing radiation even though flying or basking on the roost continues until ambient temperatures fall to levels preventing further activity.

The occurrence of abbreviated search flights during sudden radiation drops preceding thunderstorms provided additional evidence that decreasing radiation triggers such search flights. One male patrolling an area high in the field abruptly switched into erratic search flight behavior with the sudden darkening before a thunderstorm even though air temperature 1.5 m above the ground was 26.7 C. After being forced down minutes later by heavy rain, this male assumed the roosting posture in an air temperature of 20.6 C. With the return of direct sun, basking commenced.

Description of the Roost

Seventy-three percent of the plants selected for roosts were grasses, the remainder being dicotyledonous species (Table 2). Sixty percent of the roosts on dicots were on leafless scapes of dead plants from the previous season. Such plants constituted less than five percent of the total stems within any grid square in the field.

←

Figs. 1-2. Postures of *Papilio polyxenes* on the roost. 1. Adult female in dorsal basking posture on culms of grass. 2. Male in folded-wing posture on short head of *Phleum pratense*.

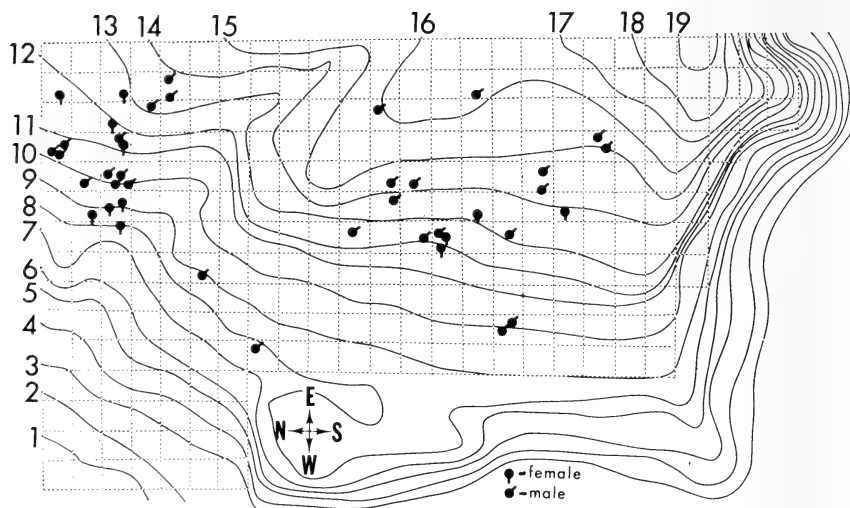


Fig. 3. Topography of study area showing location of roosts. Each small grid square is 10 m square. Numbers in margins give elevation of isoclines in meters above lowest point in field (northwest corner).

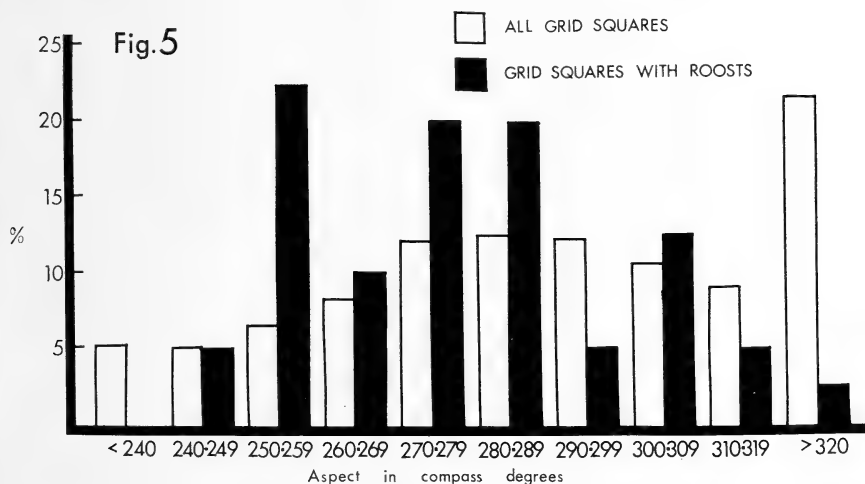
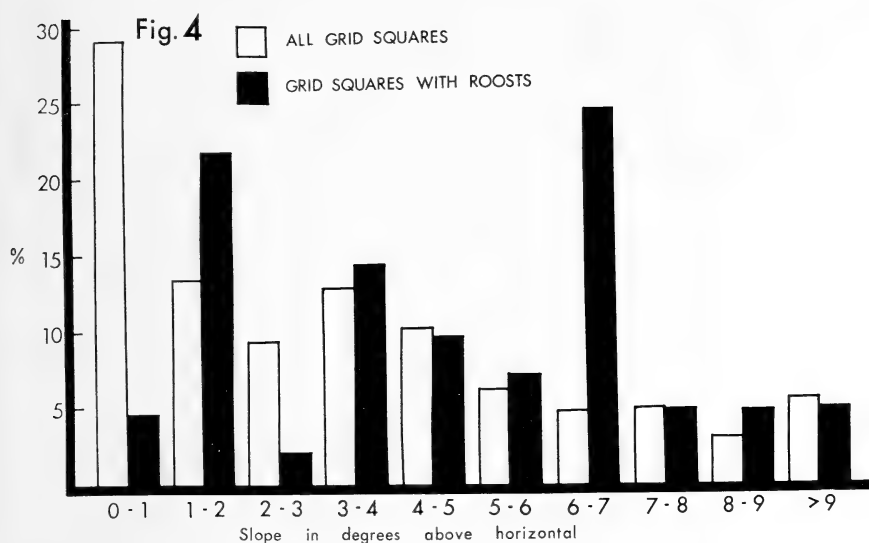
Roosts on plant inflorescences or apices were more frequent than roosts on culms or stems. Such heads may provide roosts which are easier to cling to or are less deflected by the butterfly's weight.

Butterflies on roosts are significantly closer to the ground than those perched during daily activity (Table 1). The maximum height of vegetation within a one meter radius of each roost averaged greater than twice the roost height (110 ± 17 cm, $N = 33$). Roosts were invariably in open areas of the vegetation where contact of the roosting butterfly with surrounding plants was impossible in all but the heaviest winds.

Description of the Roost Sites

Roosting occurred primarily on sites which sloped toward the west and were at the higher elevations in the field (Fig. 3). There were no differences between the roosting sites of males and those of females.

The distribution of slopes for the ten meter grid squares in which roosting occurred differed significantly from that of slopes for all grid squares in the field (Kolmogorov-Smirnov Test; $.05 > P > .01$) (Siegel, 1954) (Fig. 4). The average slope of 53 roost sites was 4.2 ± 2.5 (S.D.) degrees above the horizontal. Similarly, the distribution of aspect values toward which roost sites sloped differed significantly from that for all grid



Figs. 4-5. Frequency distributions of slope (4) and aspect (5) values for all grid squares in study area compared with distributions for only those grid squares containing roosts.

sites in the field ($P < .01$) (Fig. 5) even though the field predominantly sloped toward the west.

The density distribution of yellow goat's-beard (*Tragopogon pratensis* L.) and rough-fruited cinquefoil (*Potentilla recta* L.) for roosting sites

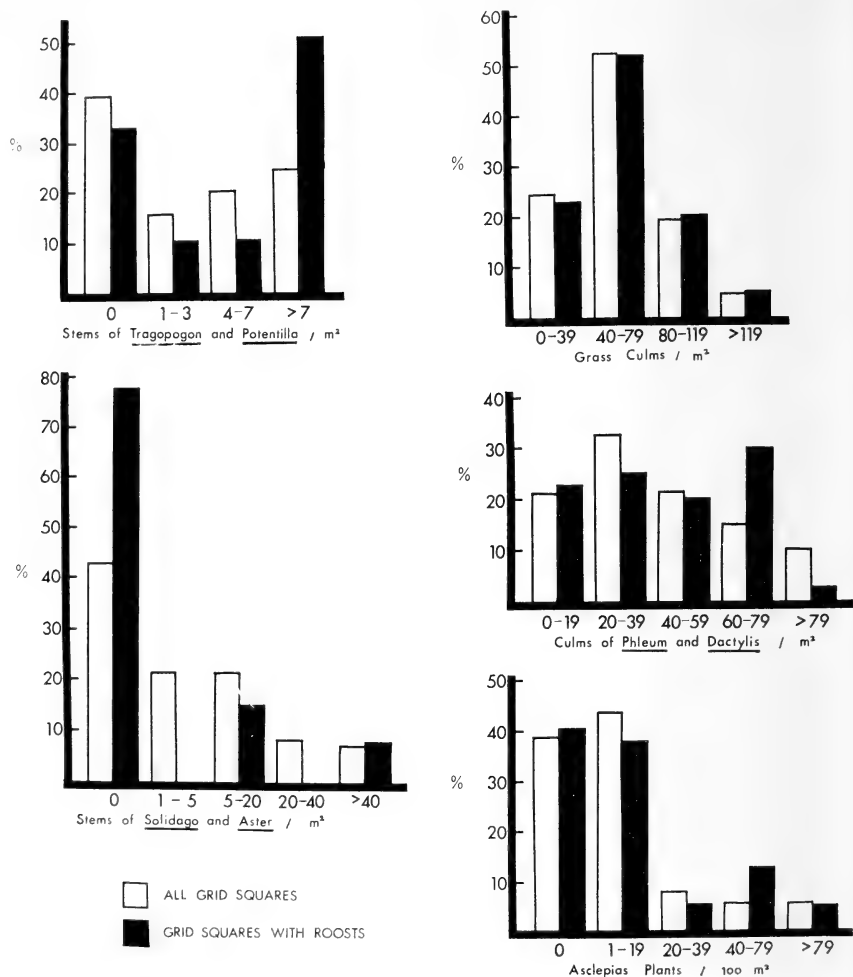


Fig. 6. Frequency distributions of various plant densities for all grid squares in study area compared with distributions for only those grid squares containing roosts.

differed significantly from that for all sites in the field, the density being higher for roosting sites (Kolmogorov-Smirnov Test; $.05 > P > .01$) (Fig. 6).

The density distribution of goldenrod (*Solidago* spp.) and New England aster (*Aster novae-angliae* L.) also differed significantly ($P < .01$). Roosts did not occur where *Solidago* and *Aster* were at highest density; these species usually form dense stands of plants which contact each other greatly in the wind.

On the other hand, density distributions of all grass species, of just orchard grass (*Dactylis glomerata* L.) and timothy (*Phleum pratense* L.) taken together, and of common milkweed (*Asclepias syriaca* L.) did not differ significantly ($P > .05$) between roosting sites and all field sites.

Survivorship on the Roost

Roosting individuals were quiescent and could easily be approached and caught by hand. Such inability to escape suggested that predation during roosting might be a major, if not the chief, cause of mortality in black swallowtail adults.

Twenty-six roosts were visited the following morning before basking occurred. Two male butterflies were missing from their roosts and were never seen again in the study area. Probability of death per night on the roost was estimated as being $2/26 = 0.077$ for all butterflies regardless of sex. Thus, an adult could be expected to live through an average of 8.7 nights assuming no other sources of adult mortality were considered $[(1 - .077)^{8.7} = 0.5]$. If only males were considered the probability of death on the roost per night was estimated by $2/21 = 0.095$. The average life expectancy of males was through 6.9 nights ignoring other sources of mortality.

DISCUSSION

Black swallowtails favor roosting sites which will allow them to continue basking for as long as possible under decreasing radiation. Selection of relatively open roost sites which slope toward the west favors the maintenance of body temperatures suitable for continued activity for as long as possible. There is no indication of any behavior which would favor warming the following morning. The presence of such behavior in other butterfly species needs more study.

The only unique behavior associated with roosting is the roost search flight. It is this flight which provides the mechanism by which a suitable roost is selected. Repetitive brief perches during this flight allow the butterfly to test and reject perches which are unstable, in the shade, or are disturbed by other vegetation. Frenetic activity during the search flight may provide enough body heat metabolically to allow flight to continue under conditions which would prevent further activity if the butterfly were motionless for a short period.

Since the search flight occurs in the sun, roosts which are finally selected tend to be on sites having the longest and most direct exposure to the setting sun. Roosting individuals on level sites are more susceptible

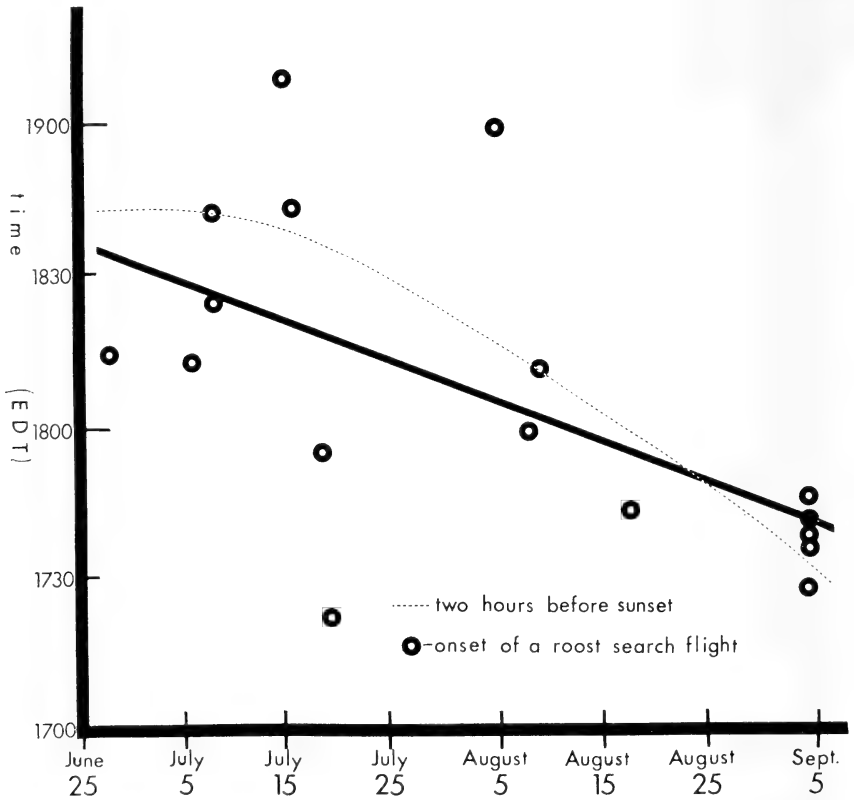


Fig. 7. Comparison of the time of onset of roost search flights with time of sunset. The solid line is a least-squares regression line of onset times with respect to date.

to being shaded by plants between them and the sun than are those on sloping sites facing the setting sun.

The onset of the erratic roost search flight is apparently triggered by decreasing radiation regardless of temperature. The shift from dorsal basking on the roost to a roosting posture with folded wings appears to occur when ambient temperature and radiation are such that body temperatures suitable for flight can no longer be maintained. There appears to be no endogenous rhythm controlling roosting. Such behavior is just as clearly associated with the onset of unfavorable conditions for flight at other times of the day.

Basking on the roost is similar to basking under more favorable conditions. There is no difference between morning and evening, making Clench's (1966) categories of "vesper" and "matutinal warming" difficult

to define for *P. polyxenes*. Basking on the roost may lengthen the period in the evening when escape from predators or selection of a different roost are still possible should a predator appear or the roost become unsuitable.

Selection for roosting behavior and roost preferences appears to be strong in view of the high mortality recorded in this study. Those individuals which fail to secure a steady, protected roost risk dislodgement and predation while cold and helpless at ground level.

In a concurrent study, Lederhouse (1978) estimated the probability of permanent disappearance per day due to dispersal and death for males after the first night of adult life to be 0.106. This value for males through the first night of imaginal life was measured as 0.532. The present estimate of male mortality on the roost (0.0953) is therefore about equal to that which Lederhouse ascribes to all causes of death plus dispersal because all marked butterflies in our study were at least two days old. It is conceivable that the large loss through the first night of adult life may be attributed to failure to find a suitable roost during that first evening or to considerable dispersal during the first day.

Death on the roost may be the chief source of mortality in this population, since not one instance of diurnal predation has been seen in over 700 hours of close observation, notwithstanding reported cases of diurnal predation by passerine birds (Erickson, 1973). Predation by ants may explain the preference shown for dead dicot scapes as roosts since ants may not frequent such plants during foraging.

If death on the roost is the major source of mortality in adult black swallowtails, then selection for mimetic or cryptic coloration patterns would probably operate most strongly on that portion of the butterfly which is exposed during roosting, the undersurface of the hindwings. We cannot help but note that the undersurface of the hindwings of members of the supposed *Battus philenor* mimetic complex are more similar in coloration than any other part of the wings. This complex includes *B. philenor* (L.), *Papilio troilus* L., *P. glaucus* L. (dark females), *P. polyxenes* F., and *Limenitis arthemis astyanax* F. (Brower, 1958). We suggest that selective advantages gained by cryptic or mimetic coloration patterns in many butterfly species may be greatest during roosting and that the exposed undersurface of the wing is more affected by such selection than is the hidden uppersurface.

In conclusion, black swallowtails select roosts which maximize exposure to the setting sun and provide stable, secure sites preventing dislodgement during the night. A roost search flight triggered by decreasing radiation is the only behavior unique to roosting and provides a

mechanism by which suitable roosts may be selected. Selection for efficient roosting is strong since death on the roost is likely to be the major source of mortality in adults.

ACKNOWLEDGMENTS

We wish to express our appreciation to Owen Sholes, Dr. Paul Feeny, and Dr. John G. Franclemont for comments on the manuscript. We thank Dr. Mark Scriber for suggestions on the implications of roost mortality on selection for wing coloration.

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NOTES ON THE LIFE CYCLE AND NATURAL HISTORY
OF BUTTERFLIES OF EL SALVADOR. IIC.
SMYRNA BLOMFILDIA AND *S. KARWINSKII*
(NYMPHALIDAE: COLOBURINI)

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ABSTRACT. Descriptions and photographs of the life histories of *Smyrna blomfildia* and *S. karwinskii* are presented, and the larval foodplants (Urticaceae) and the comparative behavioral characteristics of the two species are recorded and discussed. The present taxonomic placement of *S. blomfildia* and *S. karwinskii* is questioned, and an alternate interpretation is expressed based on the differing degrees of morphism between the two species. The adaptiveness of polymorphism is explained relative to human-disturbed habitats in El Salvador, noting that the monomorphic *S. karwinskii* is the most evolved species, but that *S. blomfildia* has a flexibility to overcome adverse conditions because of certain polymorphic characteristics. The peculiar phenomenon of a divergent evolutionary trend between the early stages (larvae and pupae) and an advergnet trend between the adults of both species is noted.

This is the second of three papers on the Coloburini (Gynaeciini) of El Salvador. Classically, *Colobura dirce* L. and *Historis odius* Fab. have been included with *Smyrna* in the Coloburini, based, no doubt, on similarities in adult characteristics. Whether or not these form a natural complex of related species is left for others to determine, who can compare the overall characteristics of *Smyrna* sp., *Colobura dirce*, and *Historis odius*.

We present here a description of the early stages of *Smyrna blomfildia* Fab. and *S. karwinskii* Hübn., records of the larval foodplants, and an account of the behavior observed in both the immatures and adults. We have reared *S. blomfildia* and *S. karwinskii* using the same techniques described for the Catonephelini, Charaxini, and Hamadryadini (Muyshondt, 1973a, 1974b; Muyshondt & Muyshondt, 1975a) with consistently uniform results. Specimens preserved in alcohol have been sent to the American Museum of Natural History, New York City.

Life Cycle

Smyrna blomfildia

Smyrna karwinskii

Egg. Almost spherical with flattened base, light green with 10 whitish vertical ribs which fade around the micropyle. Ca. 1 mm diameter. Hatches in 5 days.

Same as *S. blomfildia* in all respects.

1st instar larva. Head roundish, naked, shiny black. Body naked, cylindrical, brownish-green, with transverse rows of white, shallow, small warts on each segment. Legs and tips of prolegs dark brown. Ca. 2 mm when hatched, growing to 4.5 mm in 2 days.

2nd instar larva. Head shiny black, with short, knobby, divergent horns, one on each epicranium, and 8 small, white conical projections across head capsule, under epicranial horns. Body brown with transverse rows of tiny, forked spines implanted on white chalaza. Grows to 8 mm in 2 days.

3rd instar larva. Head reddish with thick, short horns (ca. head length) armed with secondary spines placed in the following order: a basal row of 3, 1 pointing inwards, 2 anterad; a second row, with 1 pointing caudad, 1 anterad and 1 laterad. Horns terminate distally in a club with 5 short spines. Around base of each horn are 7 spines; around the ocelli are 5 smaller spines. Body predominantly dark brown with some light spots among the spines, which are placed in the following positions: 1st thoracic segment (T-1) with 1 spine subdorsally, 1 subspiracular spine and 1 pedal spine. T-2 and T-3 with 1 subdorsal scolus with a rosette of 5 spines near tip and 1 vertically; 1 supraspiracular scolus with rosette of 4 spines and 1 vertical; 1 subspiracular spine and 1 pedal spine. Abdominal segments from A-1 to A-7 have, in addition, 1 dorsal scolus with 2 lateral spines and 1 distal, and behind the subspiracular spine 1 scolus with rosette of lateral spines and 1 distal spine. A-1, A-2 and A-7 have 1 small ventral spine in line with prolegs. A-8 has an additional scolus caudad with a 6-spined rosette. A-9 with only 1 subdorsal scolus directed posterad with rosette of 5 lateral spines and one distal. A-10 with anal shield and 2 lateral groups of small spines directed posterad. Grows to 15 mm in 2 days.

4th instar larva. Same as 3rd instar but body shows various color morphs: 1 dorsally brown with cream dots, rest of body cream also, where black spiracula

Same as *S. blomfildia*, but light green with transverse rows of white warts.

Same as *S. blomfildia*, but body lighter color and lacking dorsal spines in all but 8th abdominal segment.

Head light brown with longer and thinner horns than *S. blomfildia* ($1\frac{1}{2}$ head length). Lateral spines of head much reduced. Horn terminals more clubbed. Body color basically brown with double transverse rows of whitish dots on each segment and a broken stripe of light color subspiracularly. Spiracula black. Ventral surface dirty light gray, prolegs beige. Body with whitish scoli armed with concolored black-tipped spines, placed in the following order: T-1 with subdorsal group of 3 small spines, then 1 small supraspiracular spine, 1 small subspiracular spine and 2 small pedal spines. T-2 and T-3: 1 subdorsal scolus, short, with rosette of 6 lateral spines and 1 distal spine; 1 supraspiracular scolus with rosette of 5 lateral spines and 1 distal; 1 subspiracular spine and 2 pedal spines. Abdominal segments A-1 and A-7 have a subdorsal scolus with a rosette of 4 lateral spines and 1 distal; supraspiracular scolus with rosette of 4 lateral spines and 1 distal; subspiracular scolus with 4 lateral spines and 1 distal, then two small pedal spines. A-8 has in addition a heavier dorsal scolus armed with 8 spines. A-9 has only 1 supraspiracular scolus directed posterad, with 6 spines. Anal plate on A-10 surrounded by 6 small spines. Grows to 15 mm in 2 days.

Head dirty yellow, with some brown markings frontally. Slender horns, slightly bent in some individuals, colored light gray. All head and horn spines white with

stand out and all scoli and spines whitish. Another morph mostly black dorsally, with double row of whitish dots along meson. From supraspiracular to ventral area cream colored. Dorsal scoli white, subdorsal and supraspiracular scoli black, the rest whitish. Other morph mostly greenish-white with black stripes covering dorsal and subdorsal area, but much broken by stripes and dots of greenish-white. All scoli greenish-white with light spines. Still another morph similar to the preceding one but with subdorsal and supraspiracular scoli black. The rest whitish. Grows to 28 mm in 2 to 3 days.

5th instar larva. Same as 4th instar, growing to 41 mm in 3 to 4 days.

Prepupa. No noticeable change. Hangs from anal prolegs, body incurved ventrally. Lasts 1 day.

Pupa. From light brown to very dark brown, abdominal segments darker than the rest, with rows of lighter, shallow warts: 1 supraspiracularly, 1 subspiracularly. Spiracula inconspicuously brown. One black spot at either side between wingcase and thorax. Abdomen rounded with no sharp angles; slightly incurved ventrally, shallow depression at the thoracic union dorsally. Thorax slightly keeled to rounded head. Pointed cremaster dark brown. 25 mm long, 10 mm laterally and dorsoventrally at widest points. Adults emerge between 8–11 days.

black tips. Body ground color light gray with a darker thin mesal stripe, and transverse rows of cream colored spots at segment unions. All scoli as in 3rd instar, implanted now on bright yellow chalaza; scoli and spines white with black tips. Grows to 29–30 mm in 2 to 3 days.

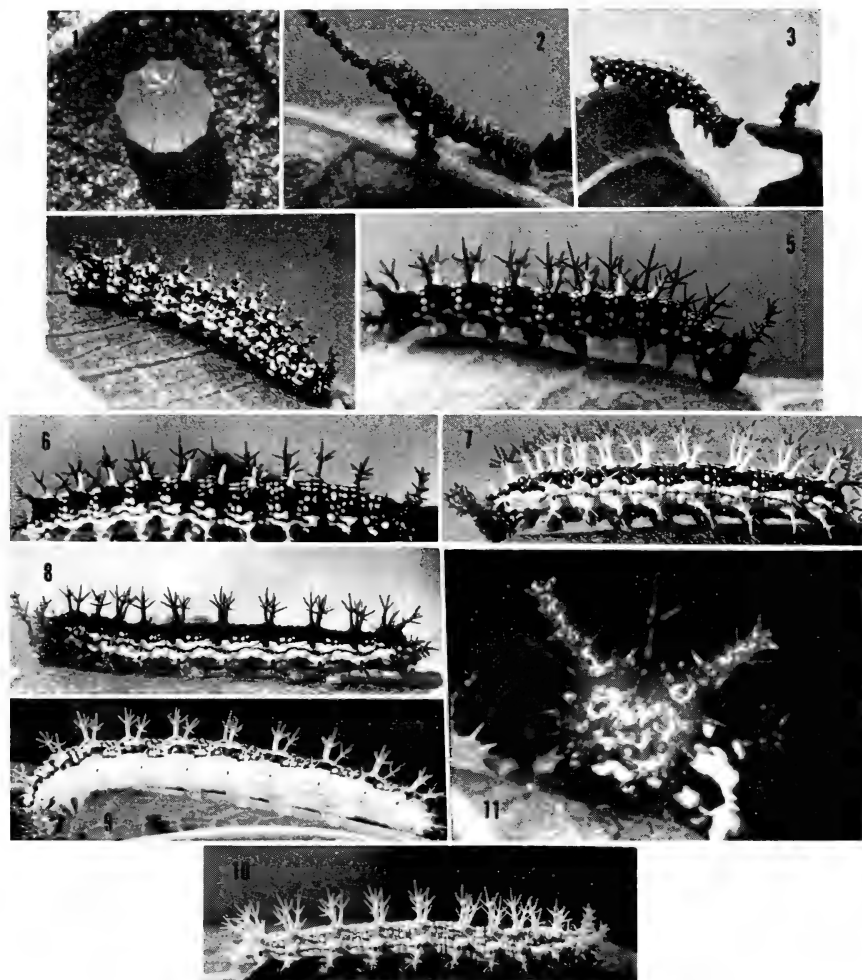
Drastic change in color. Now mostly brown with black markings on head, between dark horns and down to ocelli laterally. The whole body with black irregular marblings. All scoli shorter than in prior instars; brown colored as well as spines, legs and prolegs. Grows to 40–42 mm in 3 to 4 days.

Same as *S. blomfildia*. 1 day.

Lighter brown and thinner than *S. blomfildia*. Abdomen more humped dorsally and with 3 rows of conical spines: 1 prominent subdorsally, 1 of decreasing size supraspiracularly, and 1 still smaller subspiracularly. Thoracic dorsal keel sharply angled midways. Black spots between wingcase and thorax, as *S. blomfildia*. Black pointed cremaster set at an angle in relation to body plan. 28 mm long, 11 mm dorsoventrally, 10 mm laterally at widest points. Lasts 9–11 days.

Adults. Both species show a marked sexual dimorphism in the coloration, males being brighter than females. Wing shape is the same in both sexes.

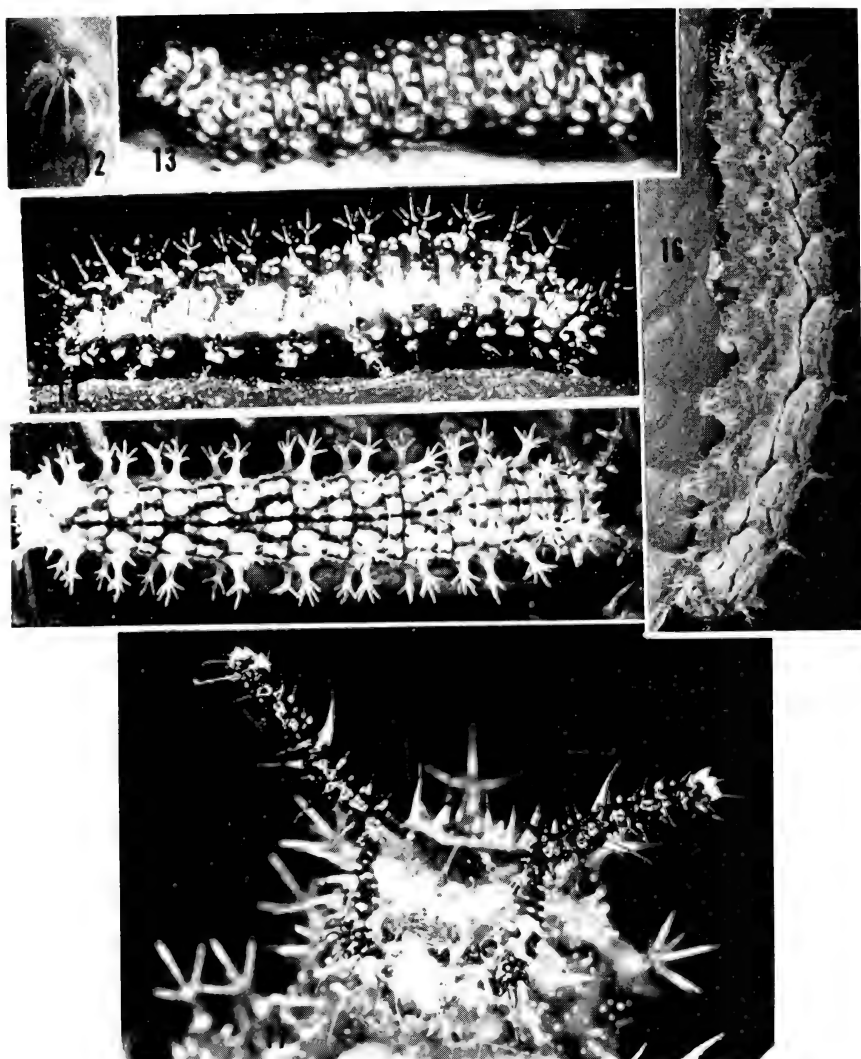
Males. Dorsally forewing golden brown in basal and discal areas with lighter golden-orange band slanting from midcostal margin to tornus. (*S. blomfildia* tends to be lighter than *S. karwinskii*.) The rest velvety black, except a subapical row of three, light yellow spots parallel to the light band. Hindwing in *S. karwinskii* golden-brown mostly, with a black edge along outer margin, 3 mm wide, near outer angle, very thin from there down along the very edge of the wing to anal angle. A submarginal row of faint black dots along the thin portion of the black edge. In *S. blomfildia* hindwing is a lighter golden-orange and black edge along outer angle becomes submarginal along



Figs. 1-11. *Smyrna blomfieldia*: 1, egg, recently deposited, 1 mm; 2 (photo upside-down), 1st instar larva, 4.5 mm (note "perch" on central vein); 3, 2nd instar larva, 8 mm (note new "perch" being constructed at edge of leaf); 4, 3rd instar larva, 15 mm; 5, 4th instar larva, 28 mm; 6-10, 5th instar larvae, various morphs, 41 mm; 11, 5th instar larva, close-up of head.

outer margin down to M_2 where it becomes thin, ending between Cu_1 and Cu_2 where it is substituted by a marginal thin edge running between the two, small toothed projections on anal angle, with a whitish dot in the interior one. Inner fold in both species fulvous gray.

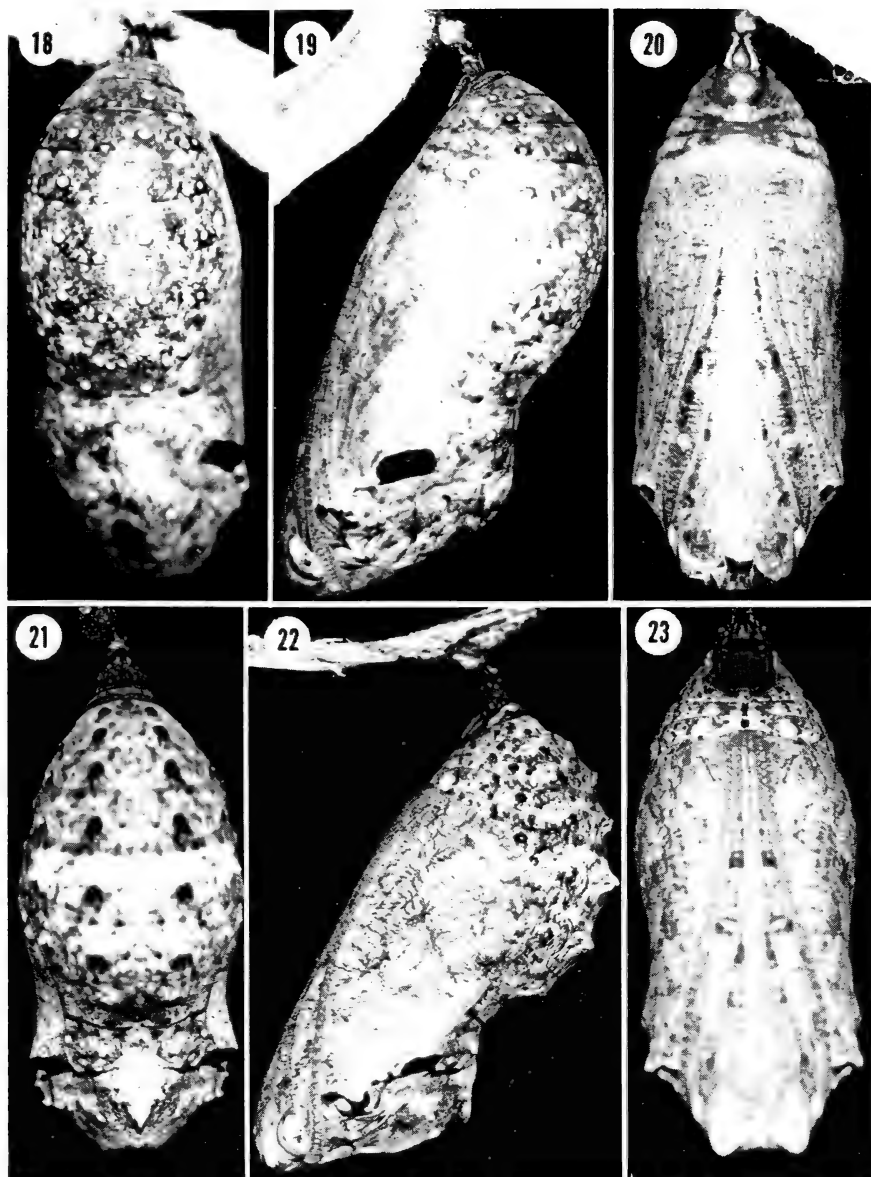
Ventrally forewing presents basally some black drawings, on light yellow basic color, which is devoid of markings from midcostal margin to tornus, except for a brownish gray border along inner margin, more so in *S. karwinskii*. From midcostal to subapical costal margin down to mid-outer margin to tornus there is a black zone



Figs. 12-17. *Smyrna karwinskii*: 12, egg, ready to hatch, 1 mm; 13, 1st instar larva, 3.5 mm; 14, 3rd instar larva, 15 mm; 15, 4th instar larva (note absence of dorsal spines and slender horns), 29-30 mm; 16, 5th instar larva (note reduced scoli), 40-42 mm; 17, 5th instar larva, close-up of head.

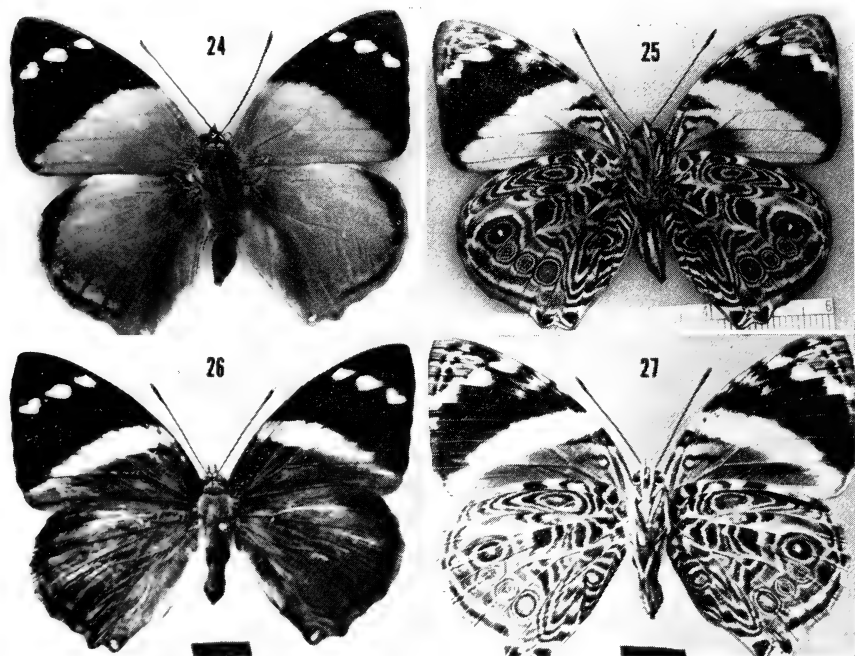
limited distally by a diffuse replica of the dorsal subapical dots, which ventrally merge with each other. Apically a gray zone mottled by faint black markings, more contrasting in *S. blomfieldia* than in *S. karwinskii*.

Hindwings show a complicated pattern of sinuous lines, circles and triangles of dark brown, light brown and whitish color, all darker in *S. blomfieldia* than in *S. karwinskii*.



Figs. 18-20. *Smyrna blomfildia*: 18, dorsal view of pupa; 19, side view of pupa; 20, ventral view of pupa.

Figs. 21-23. *Smyrna karwinskii*: 21, dorsal view of pupa; 22, side view of pupa; 23, ventral view of pupa.



Figs. 24–27. *Smyrna blomfildia*: 24, dorsal view of male; 25, ventral view of male (metric scale); 26, dorsal view of female; 27, ventral view of female.

Both species present a submarginal row of 4 “eyes” along outer margin, the two at the extremes twice as large as the two interior ones. Both species also have a black spot on the anal angles. *S. blomfildia* in addition has a second black spot on the first toothed projection.

Females. Both species dorsally have the same pattern as the males, but the golden-brown or orange is replaced by dull brown, separated from the black apical area by a light yellow band. The rest as in males and so is the underside of the wings.

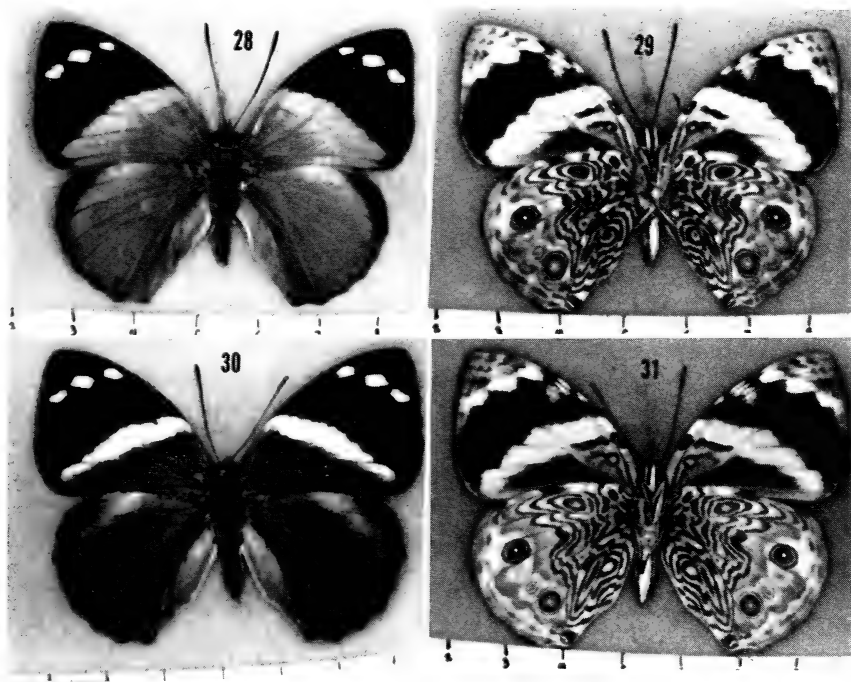
Body is concolorous to the respective wing coloration. Antennae black, ending with an orange tip, larger in *S. blomfildia*. Palpi cream colored, proboscis tanned brown. Wing span 70–80 mm. *S. blomfildia* usually larger than *S. karwinskii*, and females larger than males, more markedly so in *S. blomfildia*.

Total time from egg to adult, 25–30 days.

Natural History

Females of both species of *Smyrna* deposit their solitary eggs on the undersides of leaves of various Urticaceae. In contrast, other species of Coloburini oviposit on Moraceae. We have found the eggs of both *Smyrna* spp. on *Urticastrum mexicanum* (Ieb.) Kuntze, *Urera caracasana* (Jacquin) Grisebach, and *U. baccifera* (L.) Gaudichaud.

The fast flying females land on the undersurfaces of leaves for ovi-



Figs. 28-31. *Smyrna karwinskii*: 28, dorsal view of male (note absence of indentations in anal angles); 29, ventral view of male; 30, dorsal view of female; 31, ventral view of female.

position. This is in striking contrast to the rest of the Coloburini we have been able to study, which oviposit mostly on the upper surface of leaves. Female *Smyrna* quickly deposit one egg, then move to another plant close by where the process is repeated. It is not uncommon for the same plant to be visited again after a period of time. We have observed that females deposit more than five eggs in sequence before moving away. The plants used are generally less than 3 m tall.

The rather small eggs are quite hard to locate, due in part to the stinging properties of the plants, but also to the light green color of the eggs, which makes them inconspicuous against the color of the leaves. After 5 days the larva hatches and consumes most of the eggshell, leaving traces of the wall. It proceeds to feed on the undersurface of the leaf, where it constructs a resting perch very close to its feeding place, perpendicular to the surface. This is a notable deviation from the usual method of the other perch-making species we know, which always move to the edge of a leaf to feed, and which construct their resting perch by prolongation of a vein. In *Smyrna* spp., second instar larvae do eventually construct the

perch at the edge of the leaf. From then on, the larvae remain on the undersurface of leaves until pupation. They pupate on the same plant, either under leaves or on petioles, after hanging by the anal prolegs for one day with the thoracic segments incurved ventrally. The pupa hangs loosely from the pointed cremaster, swinging freely with the faintest movement of the plant. The colors of the wings of the pharate adult do not show through the wingcase of the pupal skin when the adult insect is ready to emerge, due to the dark color of the pupa. After emergence, a rusty-colored meconium is ejected while the insect expands its wings. The imago takes a long period of time before its first flight.

Both species show marked sexual dimorphism. At the same time, the two species are very similar to one another dorsally. The principal difference is that *S. karwinskii* has a rounded anal angle on the hindwing, where *S. blomfildia* has a small toothed projection.

We have never seen imagos of either species visiting flowers, but we have seen them feeding on sap flowing from tree wounds, fermenting fruits, mud puddles, etc., where they spend long periods of time, with their wings folded dorsally.

Smyrna karwinskii is noteworthy for its seasonal gregarious roosts in high mountains during the dry season (Muyshondt & Muyshondt, Jr., 1974). This phenomenon also occurs in Mexico (R. Wind, Chiapas, pers. comm.; Beutelspacher, 1975). We have never found eggs or larvae of *S. karwinskii* in the high mountains during the dry or the rainy season, even where the foodplants occur locally. It seems that they move down to lower levels to breed, usually in close proximity to *S. blomfildia*. The latter very seldom is found at altitudes over 1600 m and does not have the communal roosting behavior of *S. karwinskii*. It is not uncommon to collect eggs and larvae of both species on the same plant.

The adults of both species behave similarly: they have the same fast rustling flight, they perch on tree trunks with their heads pointing down, and the males have a strong territorial defensive attitude, chasing intruding butterflies of the same or different species.

To date we have not found cases of parasitism in these species, but we have very often witnessed predation by Hemiptera (Reduviidae, mostly) which impale the larvae, leaving only the sagging skin. Another cause of severe larval mortality in the fields is a disease causing the larva's body to burst, releasing a foul-smelling dark fluid.

The foodplants, known locally under one vernacular name common to the three species, "Chichicaste," are plants often used as hedges around coffee plantations, because of the severe stinging caused by the leaves which deters trespassers.

Urera baccifera grows to a height of 7 m when left alone. The trunks

and older branches are covered with short, wide spines, the younger branches and the leaves with stinging hairs. The leaves are large, coarse, round-cordate and roughly dentate. The small greenish flowers grow in cymes, producing small, translucent, globose fruits with a dark seed inside. These fruits are much sought after by farm children, who pick them by beating the shrub with a stick while catching the rain of falling fruits with a "sombbrero." Thus, hundreds are collected before disposing of them *in situ*, much to their pleasure. The juicy fruits have a sweetish-refreshing taste and alleviate thirst readily.

Urera caracasana grows to about 4 m and is also used in fences. The leaves are smaller, and of variable shapes; more or less elongate, cordate at the base and acute at the apex, with close dentation at the edges. The fruits are red when mature. Both species are used in popular medicine against venereal diseases. *Urticastrum mexicanum* is a shrub up to 4 m tall, with ovate, crenate leaves. The fruits are achenes. All of these plants have caused painful accidents to tourists unaware of the severe stinging properties of the otherwise handsome leaves.

DISCUSSION

Smyrna blomfildia is the type-species of the genus *Smyrna* Hübner, based on the butterfly originally named *Papilio blomfildia* by Fabricius in 1781 (Hemming, 1967). As he very often did, Hübner misspelled the specific name as "blomfildii," and this erroneous spelling was subsequently used by several authors, among them Herrich-Schäffer (1864) and Müller (1866), with an additional error: "blomfieldii." Other authors named the species *S. bella* Godart and *S. pluto* Westwood (Seitz, 1921).

The only other reports of the early-stages of this genus that we are aware of are by Müller, who gave a short description of a probable 4th instar larva preserved in alcohol, some rough descriptions based on that of Müller's (Seitz, 1921; Hayward, 1964), and a vague comparison between the larvae of *Colobura* and *Smyrna* by Brown & Heineman (1972). We believe that ours is the first complete description of the early stages, with photographic illustrations of both *Smyrna blomfildia* and *karwinskii*.

The genus *Smyrna* has been placed in various unrelated groups based mostly on the external characters of the perfect insects by many early authors. Doubleday, Westwood and Hewitson (1849) and Boisduval (1870), placed it close to *Agrias*. Herrich-Schäffer (1864) put this genus in his "familie XI," together with the related genera *Gynaecia* and *Callizona*, and many unrelated ones, among them *Euptoieta*, *Eunica*, *Pyrrhogyra*, *Ageronia*, *Peridromia*, *Amphichlora*, etc. Schatz & Röber (1892), placed *Smyrna* in their "Gynaecia-Gruppe," as part of their

larger "Eunice-Gruppe," together with *Callizona* and *Gynaecia* (*Colobura*), probably following Herrich-Schäffer.

Today, many authors follow Seitz (1921), who was probably influenced by Reuter (1898) in placing *Smyrna* in his "Gruppe Gynaeciidae," together with *Historis*, *Coea*, *Pycina*, *Megistanis*, *Gynaecia* and *Callizona*, as an intermediate group between his "Gruppe Epicaliidi" including many genera (*Catonephele*, *Epiphile*, *Temenis*, *Pseudonica*, *Pyrrhogyra*, etc.) covered by one of us (Muyshondt, 1973a, b, c, d; 1974a) in previous papers and his "gruppe Hypolimnadidi," with *Hypolimnas misippus* L. Other modern authors include this genus and related genera (*Historis*, *Coea*, *Colobura*, etc.) in the Limenitidini which we believe is erroneous.

Different opinions arise, no doubt because of superficial similarities of the adults, which could very well be due to convergent evolution rather than close relationship. Examples are well known of convergence in color, pattern, and shape between unrelated species actually belonging to different families: i.e. Danaidae, Ithomiidae, Heliconiidae and Pieridae. These often form Müllerian and Batesian mimicry complexes, as pointed out by many biologists (Brower, 1972; Brown & Benson, 1974).

The very poor knowledge of the immatures of most tropical butterflies has led to errors in the association of species. Descriptions of the immature stages are necessary for a more accurate systematic arrangement of the neotropical Lepidoptera.

Comparison of the eggs of the two species of *Smyrna* indicates that they are very closely related. Larvae and pupae are also very similar, although the larvae of *S. karwinskii* lack the dorsal row of scoli present in *S. blomfieldia*. In contrast, the eggs, larvae and pupae of *Smyrna* differ considerably from those of *Colubura dirce*. The immature stages of *Historis odius* and *Coea acheronta* resemble each other closely, but have nothing in common with *Colobura*, and only the larval head shape resembles *Smyrna*.

There are so many drastic differences between the characteristics of the early stages of the species of Coloburini studied by us [*Colobura dirce* L. (Muyshondt, Jr. & Muyshondt, 1976), *Historis odius* (Fab.) and *Coea acheronta* (Fab.), (Ms. in prep.)], that we question the correctness of the taxonomy of the group.

However, we feel that although *Smyrna* is an aberrant genus in the Coloburini, it represents a link between the Nymphalini and the other genera now included in the Coloburini.

By the same token it is also evident that none of these species can be placed in the Charaxinae, as was done by Boisduval (1870), who placed *Smyrna* between *Agrias* and *Prepona*, and said that the larvae of

Aganisthos (= *Historis*) and *Prepona*, "sont tout-à-fait semblables" (exactly alike). This is absolutely incorrect! *Prepona* and *Archeoprepona* do resemble each other in the shape of the eggs, larvae and pupae (Muyshondt, 1973e; Muyshondt, 1976), but neither stage resembles even remotely the early-stages of *Historis* (Ms in prep.). To include *Smyrna* with the Limenitidini (in which *Adelpha* belongs) as most modern authors do, is also incorrect, as they have nothing in common with the Coloburini during their early stages. With Limenitidini there are certain imaginal resemblances, but these are not strong enough to place them together.

It is noteworthy that the larvae of both species of *Smyrna* construct a resting perch with frass pellets. Other larvae which use this defensive strategy construct their perch at the edge of the leaf on which they live: some of them pile a barrier of excreta mixed with pieces of dry leaf tissue at the base of the perch (*Adelpha* spp.); some fasten leaf cuttings with silk which hang from the perch (*Zaretis*, *Prepona*, *Archeoprepona*); many others leave the perch bare (*Biblis*, *Mestra*, *Catonephele*, *Epiphile*, *Nica*, *Temenis*, *Pyrhogyra*, *Diaethria*, *Catagramma*, *Cyclogramma*, *Hamadryas*, *Colobura*, *Historis*, *Coea*, *Apatura*, *Marpesia*). As far as we have been able to ascertain only the two species of *Smyrna* construct a perch on the underside of a leaf, very close to where the eggshell was consumed. During the 2nd instar, a new perch is sometimes made at the edge of the leaf; the other species mentioned also do this. We interpret this behavior to result from protection afforded to the small larvae by the strong urticating properties of the foodplants, a factor which by itself might deter at least some predators. After the 2nd instar the larvae abandon their perch and wander about the plant on the underside of the leaves. Perhaps the urticating properties of the plant afford continued protection. It is to be noted that the profusion of spines displayed by the larvae of *Smyrna* spp. from the 3rd instar on do not have urticating properties. Even the ventral prothoracic gland (adenosma), is not readily extruded as in *Colobura dirce* and other species provided with this apparent means of defense. Thus, it seems that the larvae of *Smyrna* rely on the protection granted by the plant itself, rather than on the protection they could derive from their own spines and odoriferous gland.

One thing puzzles us: although the adults of the two species of *Smyrna* are strikingly alike, why is it that the larvae and even pupae of the two species show important differences, such as the unequal number of rows of scoli in the larvae, and the different shape of the pupae?

We have seen various larvae and pupae of species belonging to the same genus, the adults having a common shape but with very disparate

coloration, such as *Siproeta stelenes* (Young & Muysshondt, 1973) and *V. epaphus* (Young, 1972), *Heliconius petiveranus* and *H. charitonius*; *Anartia fatima* and *A. jatrophae*. Still others show differences not only in color, but in the shape of the wings of the adult, as do *Catonephele numilia* and *C. nyctimus*. Yet the larvae and pupae, except for minor discrepancies, if any, have the same characteristics, indicating that they undoubtedly both belong to the same genus. We have seen, on the other hand, species placed in the same genus which have very basic differences during their early stages, for example *Hamadryas februa*, *H. guatemalena* and *H. amphinome*; and *Anaea eurypile*, *A. morvus* and *A. pithyusa*, suggesting that they may belong to different but related genera of one subfamily or family (Muysshondt & Muysshondt, Jr., 1975a, b, c; Muysshondt, 1974b, 1975a, b). For these reasons, regardless of the striking resemblances in adult coloration and shape between *Smyrna blomfildia* and *S. karwinskii*, we suggest they might belong to different genera. They would then form another case of evolutionary convergence, perhaps of Müllerian mimicry. While *S. blomfildia* seems to be in the process of finding its optimum larval characteristics, as suggested by the striking polymorphism in larval coloration, *S. karwinskii* apparently has already achieved stability as it has only one morph. We consider *S. karwinskii* as the most evolved of the two, because of the uniformity of characteristics maintained during its whole life cycle, and thence the model of the two. *S. blomfildia* we consider to be the youngest, still an evolving species. This evolutionary phase seems to have momentarily given *S. blomfildia* an advantageous flexibility to overcome adverse conditions which are reflected in a more abundant population than its more stable relative, *S. karwinskii*, at least under the conditions in El Salvador where the habitats are continuously and severely affected by human influences, due to the high population density.

It would be interesting to read an explanation of the present phenomenon, where two species evolve divergently during their early stages, yet seem to evolve advergently during their adult stage. Most of the work of which we are aware on the evolution of butterflies has concentrated on their adult stage, disregarding almost completely their early stages, which perhaps would throw new light on the problem.

ACKNOWLEDGMENTS

We wish to express our gratitude to all the people who helped us with their guidance, provided reference material, and revised our manuscript to make it presentable, especially Drs. A. B. Klots, A. B. H. Rydon, J. G. Sternburg, and G. L. Godfrey. This paper would not have been possible

without the great help received from Marilyn and Pierre Muysshondt, who did much of the fieldwork and observations.

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SCELIODES LAISALIS (PYRALIDAE): DESCRIPTION OF THE MATURE LARVA AND NOTE ON ITS FEEDING HABIT

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ABSTRACT. Mature laboratory-reared and field-collected larvae of *Sceliodes laisalis* Wlk. (Pyralidae) are examined and described and the chaetotaxy illustrated. A brief note on the feeding habit of this species, an economic pest of *Solanum* fruits in southwestern Nigeria, is given.

Taxonomy of immature insects has long been neglected in Nigeria; mostly, general descriptions of immature stages are contained in publications on the biology of some species. Where a complex of species is involved, most taxonomic studies and identifications were of adults. In contributing to the growth of taxonomy of immatures, I here describe the larva of *Sceliodes laisalis* Wlk. and illustrate its chaetotaxy. Its feeding habit is also described.

Sceliodes laisalis, widely distributed in southwestern Nigeria (Akinlosotu, 1977), is an economic pest of the garden egg fruit, *Solanum macrocarpon* L. and *S. melongena* L. (Solanaceae). Larvae reduce the quality and quantity of the fruits and the seeds.

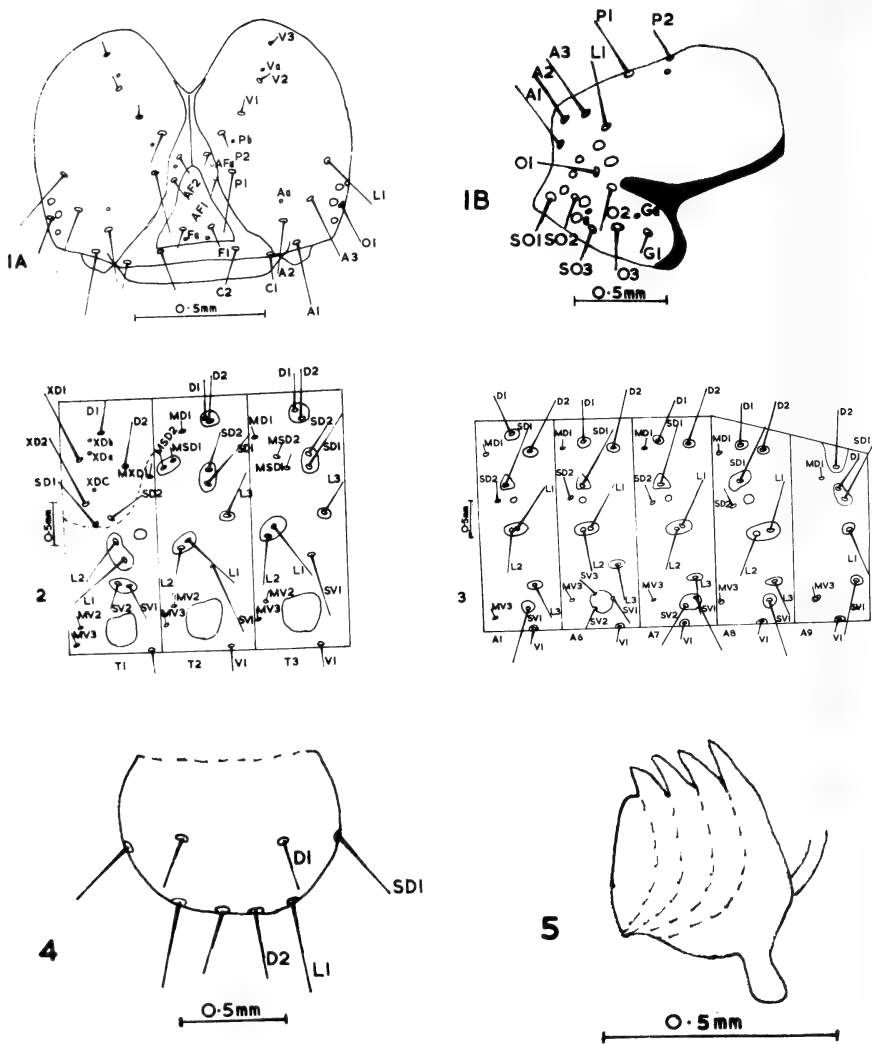
My descriptions are based on 15 field collected specimens and 25 larvae reared in the laboratory. In the following description, names of setae follow Hinton (1946). To describe the feeding habit at Ibadan, I examined fruits of ten *S. macrocarpon* and *S. melongena* cultivars and those of *Capsicum annuum* L., *C. frutescens* L., and *Lycopersicum esculentum* Mill. for *Sceliodes* attack.

Description of Larva

General. Length 16.0-22.4 mm, mean = 17.6 mm; width 3.0-4.1 mm, mean = 3.3 mm. Head yellowish brown often with dark brown maculation; ocellar area deep brown, a fuscous band occurs from post-occiput narrowing towards but not reaching the ocellar area (Fig. 1B). Prothoracic shield pale with brown spots and deep brown areas postero-medially; mesothorax suffused with brown; thoracic legs brown. Abdomen pink dorsally excepting the deep brown anal shield; venter pale. Setal pinacula light brown. Spiracles circular, yellowish with brown rim; prothoracic and 8th abdominal spiracles each larger than the others.

Head (Fig. 1A). Width 1.1-1.5 mm, mean = 1.2 mm; subspherical in frontal view. Adfrontal suture reaching the acutely angled vertex. Labrum shallow and emarginate, mandible with 5 teeth, all but the distal one pointed (Fig. 5), mesal surface with 4 ridges.

Each of the first, second and the sixth ocellus larger than the others; the second ocellus closer to the first than to the third. Posterior seta P2 about $\frac{1}{2}$ the length of P1;



Figs. 1-5. Chaetotaxy of *Sceliodes laisalis* larva. 1, head, frontal view (A) and lateral view (B); 2, thoracic segments; 3, first, sixth through ninth abdominal segments; 4, anal shield; 5, right mandible.

this inserted about mid-length of the head. Seta P1 closer to adfrontal seta AF1 than to AF2. Distance from AF2-AFa puncture one-third to one-half that from AF2-AF1. Fa punctures well below frontal setae F1; distance between these one-half to three-fourths that between clypeal setae C2. A2, A3, and L1 setae obtuse angled. Vertical setae V1 slightly antero-ventrad from V2; this closer to V3 than to V1. Ocellar seta O1 close to the 3rd ocellus, O2 seta ventrad from the 1st ocellus. Distance from genal seta G1-Ga puncture less than $\frac{1}{2}$ that between O1-Oa puncture.

Thorax (Fig. 2). Seta MxD1 outside prothoracic shield. On this seta XD2 dorsad from and closer to SD1 than to XD1. On meso- and metathorax each of dorsal and subdorsal setae on the same pinaculum; lateral seta L3 postero-dorsad from L1; distance from MV2–MV3 about one-third that from MV3–V1. On mesothorax MSD1 and MSD2 on the same pinaculum but on separate pinacula on metathorax. Prothoracic coxae close but not touching, mesothoracic coxae about the coxal width apart, and the metathoracic coxae generally more than the coxal width apart.

Abdomen (Fig. 3). D1 and D2 pinacula equal in size and closer on the 8th than on other segments. On the 9th segment, dorsal setae D2 on the same pinaculum; D1, a thin seta, is slightly closer to SD1 or equidistant between D2 and SD1. Seta MD1 antero-ventrad from D1 on segments 1–8; lateral pinaculum larger on the 8th than on the other segments.

Subventral setae. 1: 3: 2: 1: 1 on segments 1, 2, 7–9, respectively. Distance between V1 pinacula on the 7th segment more than $2\times$ that of the 9th segment.

Anal shield (Fig. 4). Rounded posteriorly, SD1 setae slightly to well above D1 setae. Prolegs on segments 3–6 with crochets, in biordinal mesoserries, respectively numbering 16–22, mean = 19; 17–22, mean = 20; 17–23, mean = 22; and 18–24, mean = 22; and on anal proleg, 14–17, mean = 16.

Description of Feeding Habit

In feeding, larvae tunnel within the fruit which shows no external sign of damage while larvae are small. The mature larvae exit through holes made on the fruit. These holes serve as entry sites for decay organisms, whose activities eventually cause fruit rot. The cultivars of *S. macrocarpon* and *S. melongena* sampled ($n = 5$ for each) were all attacked by *Sceliodes* larvae. Two to five larvae were found within each fruit. I found no *Sceliodes* larvae in fruits of *Capsicum annuum*, *C. frutescens*, and *Lycopersicum esculentum* and neither did Akinlosotu (1977), but Davis (1964) recorded these as hosts of *Sceliodes cordalis* (Dbld.) larvae.

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MIGRATION AND RE-MIGRATION OF BUTTERFLIES THROUGH NORTH PENINSULAR FLORIDA: QUANTIFICATION WITH MALAISE TRAPS¹

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ABSTRACT. Malaise traps with single linear barriers perpendicular or parallel to the axis of the Florida peninsula were operated from 18 Sept. 1975 to 17 Sept. 1976 near Gainesville; insects intercepted by the two surfaces of each barrier were captured separately allowing them to be scored as flying northward, southward, eastward, or westward. During the fall, significantly more individuals were caught flying southward than northward for eight species of butterflies: *Urbanus proteus* (Linnaeus); *Phoebis sennae* (Linnaeus); *Precis coenia* (Hubner); *Panoquina ocola* (Edwards); *Agraulis vanillae* (Linnaeus); *Lerema accius* (Smith); *Urbanus dorantes* (Stoll); and *Eurema lisa* Boisduval and Le Conte. Estimated net numbers flying southward across each meter ranged from 3956 (*U. proteus*) to 33 (*E. lisa*). During the spring significantly more individuals were caught flying northward than southward for two species: *P. coenia*, *A. vanillae*. Estimated net numbers were 150 and 10 per m, respectively. Malaise traps can continuously and effectively monitor insect migration within the boundary layer.

Long-distance flights by insects are frequent and of theoretical and practical interest (Williams, 1958; Johnson, 1969; Dingle, 1972). Such movements are difficult to study because quantification requires identifying flying insects and determining their directions of movement as well as counting them. Most long-distance flights of insects may occur at night or at high altitudes making detailed observations impractical, although mass flights above 10 m can be studied with radar (Schaefer, 1976; Riley, 1975). Direct visual observation is useful for large insects that fly low in daylight. Butterflies have been the most frequent subjects of such observations (Arbogast, 1966; Baker, 1968b; Balciunas and Knopf, 1977). Since direct observation is difficult and time consuming, the resulting data are generally skimpy and likely to be biased by choice of observation times.

Malaise traps (Southwood, 1966) can complement direct observation of flights of low flying insects by continuously sampling without the presence or bias of an observer. Appropriately modified, a Malaise trap can separate insects flying in one direction when intercepted from those flying in another direction. I used four such traps to monitor insect flights within 2 m of the ground for one year near Gainesville, Florida.

¹ Florida Agricultural Experiment Station Journal Series No. 457.



Fig. 1 (above). N-S trap at Green Acres site, looking NNW.

Fig. 2 (below). Heads at one end of trap, showing how insects from the two sides of the barrier were kept separate.

METHODS

Special Malaise traps (Fig. 1) were constructed and are now commercially available.² Each trap had a 2.6×6 m central barrier. Insects flew into the trap by either of two 2×6 m openings that faced in opposite

² D. A. Focks & Co., P. O. Box 12852, University Station, Gainesville, Fla. 32604.

directions. Upon striking the central barrier they sometimes worked their ways toward either end, through a truncated funnel, and into a receptacle where they were killed by vapors from pieces of dichlorvos-impregnated plastic.³ Traps were made so that insects entering through one opening remained separated from those entering through the other opening (Fig. 2). The receptacles were emptied daily or two or three times per week depending on the numbers caught. Insects caught within the trap but not present in the receptacles were killed and added to the appropriate batch.

Mating status of samples of female migrants was determined by dissecting for spermatophores.

Traps were set at two sites, 15 km apart: (1) Green Acres Farm, Agronomy Dept., U. of Fla., 18 Sept.–18 Oct. 1975 (4 traps); 19 Oct.–2 Nov. 1975 (2 traps); 10 Apr.–6 June 1976 (2 traps); (2) Archer Road Laboratory, Entomology and Nematology Dept., U. of Fla. 19 Oct. 1975–17 Sept. 1976 (2 traps). The first site was an open field with no buildings or woods within 100 m (Fig. 1). The second was a lawn-like area with buildings 50 m to the west and east. Traps were set in pairs with one member of each pair oriented WSW–ENE (perpendicular to the axis of the Florida peninsula and to the predicted track of migrants—henceforth called a N–S trap) and the other (an E–W trap), 30 m away, NNW–SSE (parallel to the axis of the Florida peninsula and at right angles to the N–S trap).

The insect-catching devices (heads) of the traps were improved during the first month of the study by changing the receptacles from translucent polypropylene jars to transparent bags (Fig. 2). Even with improved heads, a trap captured only a small portion of the insects that flew over the 6-meter line defined by its barrier. The efficiency of traps was estimated from counts of individuals captured versus individuals evading capture during observation periods (4, 5, 12, and 26 Oct., 1975).

RESULTS

For eight species of butterflies the N–S traps caught significantly more individuals flying southward than flying northward in the fall (Table 1). For two of the eight, N–S traps caught significantly more individuals flying northward than flying southward in the spring.

Estimating net numbers moving southward (or northward) each week or each season requires not only counts of individuals caught but also an estimate of trapping efficiency. During the four observation periods to determine efficiency of N–S traps with improved heads, 28 of 314 *Urbanus*

³ e.g. 3 \times 6 cm pieces of No Pest or Stable Strip, Shell Chemical Co.

TABLE 1. Numbers of individuals trapped flying northward and southward and estimated net displacement¹ (in parentheses) during four seasons, 18 Sept. 1975–17 Sept. 1976, near Gainesville, Fla.

	"Fall"			"Winter"			"Spring"			"Summer"		
	26 Aug.–26 Nov. ²			27 Nov.–25 Feb.			26 Feb.–26 May			27 May–25 Aug.		
	N	S	(net/m) ¹	N	S	(net/m)	N	S	(net/m)	N	S	(net/m)
<i>U. proteus</i>	38	245 ³	(3956)	4	5		0	1		3	1	(3)
<i>P. coenia</i>	17	178 ³	(312)	2	5	(2)	155 ⁴	45	(150)	4	4	
<i>P. semmae</i>	10	244 ³	(368)	0	2	(3)	2	0	(4)	0	1	
<i>P. ocola</i>	1	164 ³	(210)	0	0		1	1		0	0	
<i>A. vanillae</i>	0	93 ³	(127)	0	0		11 ⁴	2	(10)	5	2	(4)
<i>L. accius</i>	9	54 ³	(74)	0	0		3	0	(2)	0	0	
<i>U. dorantes</i>	15	46 ³	(41)	0	0		0	0		0	0	
<i>E. lisa</i>	2	17 ³	(33)	0	0		0	0		0	0	

¹ Estimated number moving in one direction across a 1-m WSW–ENE line in excess of those moving in opposite direction. These estimates do not correlate perfectly with numbers trapped because they take into account number of traps operating and whether original or improved heads were in use (see text).

² 18 Sept.–26 Nov. 1975, 26 Aug.–17 Sept. 1976.

³ Significantly more flying southward than northward ($P < 0.05$).

⁴ Significantly more flying northward than southward ($P < 0.05$).

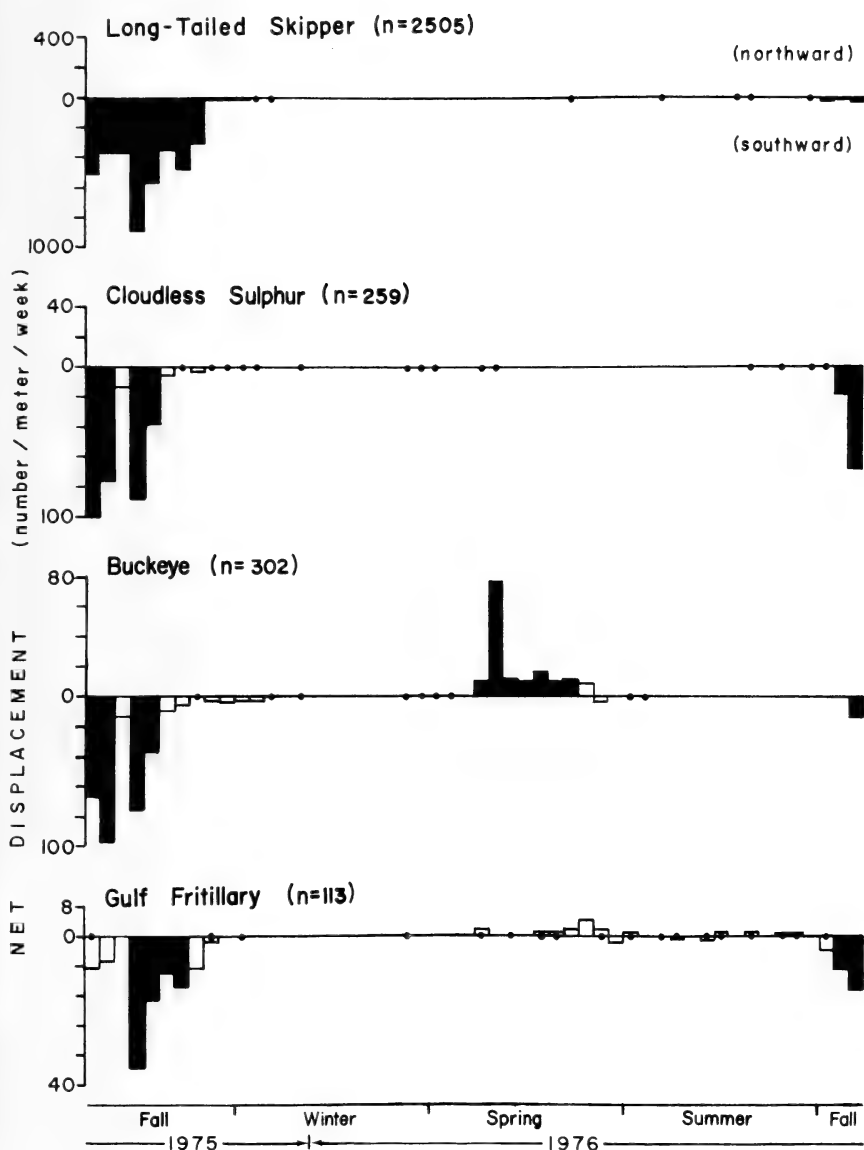
proteus (8.9%) were captured. The efficiency for single observation periods varied from 2 to 12%: 3 of 28 (11%), 19 of 159 (12%), 2 of 88 (2%), 4 of 39 (10%). The lowest efficiency (2%) occurred when the wind was mainly from the north and the skippers were flying higher than usual: 70% flew over the trap without first hitting the barrier compared to 38–43% for the other three periods. So few of the other species were flying that no reliable estimate of capture efficiency was obtained. During the four observation periods 2 of 8 *Precis coenia* were captured, 0 of 7 *Phoebis sennae*, and 0 of 3 *Agraulis vanillae*. None of these ratios differ significantly from the 8.9% observed for *U. proteus* (chi square, $P > 0.05$). To simplify calculation of estimates of net displacement (Table 1 and Fig. 3) while keeping well within the limits suggested by the data on trapping efficiency, I assumed that each trap with improved heads captured 10% of the individuals flying over its 6-m line. For N–S traps with original heads, I assumed a 2.5% efficiency, since when operated simultaneously with N–S traps with improved heads their catches were approximately one-fourth as great (e.g. 115 compared to 469 *U. proteus*). Conversion to improved heads was completed 17 Oct. 1975.

E–W traps caught approximately the same number of insects flying eastward as flying westward. The only significant exception ($P < 0.05$) was for *U. proteus*; 432 were caught in eastward flight versus 177 in westward flight (=2.4:1) during 18 Sept.–17 Nov. Such a bias would be expected if the average track of southbound migrants was east of SSE (158°), the orientation of the central barrier of E–W traps. Balciunas and Knopf (1977) determined that the mean track was 147° —i.e., 11° east of SSE.

Beginning 2 Nov. counts of individuals caught in each end of all traps were recorded separately. The north and south ends of E–W traps showed approximately the same biases as the north and south sides of N–S traps. For example, of the 144 *U. proteus* trapped 2–17 Nov. in one E–W trap, 137 were caught in the south end. (Data from E–W traps were never used in estimating net displacement northward or southward.) The fall flights lasted for six weeks or longer (Fig. 3). The continuous nature of the fall

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Fig. 3. (Top to bottom) *U. proteus*, *P. sennae*, *P. coenia*, *A. vanillae*. Weekly occurrence and net displacement northward or southward 18 Sept. 1975 through 17 Sept. 1976. Downward bars show net displacement southward; upward bars show net displacement northward. Solid bars indicate a significant ($P \leq 0.05$) inequality in numbers caught flying northward and southward. The lengths of the bars show the estimated numbers of individuals flying southward (or northward) across 1 m perpendicular to the axis of the Florida peninsula in excess of those flying in the other direction. Estimates were made from the numbers caught in 1 or 2 N–S traps. Traps



with original heads (18 Sept.-16 Oct. 1975) were assumed to be 2.5% efficient; traps with improved heads (11 Oct. 1975-17 Sept. 1976) were assumed to be 10% efficient (see text). Since the final "week" had 9 days (9-17 Sept.), its estimates were multiplied by 7/9 prior to plotting. Bars without dots indicate weeks in which numbers caught flying north and south differed by more than one (N-S traps). Dots indicate other weeks in which at least one individual was caught (all traps). Bars with dots (gulf fritillary only) indicate one individual caught flying north or south that week. Dates for seasons are as in Table 1.

TABLE 2. Sex ratios during fall and spring flights and mating status of females.

Species	Dates	Individuals Sexed	Sex Ratio (M/F)	Females Dissected	Percent Mated
<i>U. proteus</i>	9 Oct.-19 Nov.	926	.72 ¹	298	21
<i>P. sennae</i>	9 Oct.-19 Nov.	86	.87	37	35
<i>P. coenia</i>	9 Oct.-19 Nov.	116	1.11	42	64
	21 Mar.-14 May	94	2.20 ²	30	80
<i>P. ocola</i>	9 Oct.-19 Nov.	90	1.00	39	62
<i>A. vanillae</i>	9 Oct.-19 Nov.	53	.66	26	77
	5 Apr.-14 May	7	.40	5	100

¹ Significantly different from 1.00 ($P < 0.05$).² Significantly different from 1.00 and from 1.11 ($P < 0.05$).

flights is not adequately documented in Fig. 3. The small numbers caught prior to changing to improved heads exaggerated the fluctuations during the first four weeks. Only for *U. proteus* were sample sizes large enough during this period to give acceptable precision to estimates of net displacement. The day-to-day continuity of the southward flights of *U. proteus* is revealed by the occurrence of such flights on each of the 52 days that the traps were operated between 18 Sept. and 12 Nov. (Storms blew down all traps on the other 4 days during this period.) The smallest one-day catch was 5 (1 flying northward and 4 southward) and the greatest was 149 (1 and 148 respectively).

Males and females participated in fall and spring flights. With two exceptions the sex ratios of migrants did not differ significantly from 1.00 (M/F): Females were significantly in excess of males for *U. proteus* in the fall, and males were significantly in excess of females for *Precis coenia* in the spring (Table 2). Percent of females that had mated varied with the season and species from 21 to 100 (Table 2). Mated females generally contained mature eggs.

DISCUSSION

The Flights

The questions of where trapped individuals of the eight species listed in Table 1 came from, where they would have gone, and what they would have done once there cannot be answered from the results of this study or of earlier studies of one or more of the species (e.g., Williams, 1958; Arbogast, 1966; Urquhart and Urquhart, 1976; Richman and Edwards, 1976; Correale and Crocker, 1976; Balciunas and Knopf, 1977; and Edwards and Richman, 1977). Clues to the answers are provided by the following information on northern limits and overwintering stages (Howe, 1975; Klots, 1951).

Urbanus proteus (Linnaeus) (Pyrginae) occurs northward to Con-

necticut and Arkansas and is not known to overwinter in the U.S. except in Florida (Howe, 1975). In this study significant southward displacement ceased by late November, yet adults remained abundant about the flowers of *Bidens pilosa* Linnaeus until a hard freeze occurred 19 Dec. The next ones seen were three individuals, trapped 3 May, 10 June, and 19 July. Greene (1971) reported that adults were seldom seen at Sanford, Fla. (140 km SE of Gainesville) from 1 Jan. to 1 July during 1967, 1968, and 1969.

Precis coenia (Hubner) (Nymphalidae) occurs northward to Wisconsin, southern Ontario, and New England. Gorlick (in Howe, 1975) stated that "adults hibernate in winter," but did not indicate how far northward such hibernation is known. In this study adults were trapped during December and February but none was seen or trapped during January nor for the 104 days between 3 June and 16 Sept. 1976.

Phoebis sennae (Linnaeus) (Pieridae) occurs north to Canada but is not known to overwinter in U.S. except in the Gulf region and Florida. Adults are seen in Gainesville throughout the winter (though none was trapped during January 1976; cf. *Precis coenis*). The two specimens captured in N-S traps during spring 1976 were flying northward. None was trapped or seen between 31 Mar. and 28 July.

Panoquina ocola (Edwards) (Hesperiinae) occurs northward to Arkansas and New Jersey. None was trapped between 16 Dec. and 8 Mar.; 6 were trapped from 8 Mar. through 10 May; none between 10 May and 3 Sept.

Agraulis vanillae (Linnaeus) (Heliconiidae) occurs northward to Wisconsin (Schwehr, 1971). No stage survives the winters in Kansas (Randolph, 1927). After the 19 Dec. 1975 freeze in Gainesville, no adults were seen or trapped until 12 Feb.

Lerema accius (Smith) (Hesperiinae) occurs northward to New England and Illinois. During this study the only records were fall catches (5 Sept.-17 Nov.).

Urbanus dorantes (Stoll) (Pyrginae) is common in southern Texas and the Greater Antilles but only recently (1969?) became established in Florida (Knudson, 1974). The Florida population belongs to the Texas rather than to either of the Antillean subspecies (Miller and Miller, 1970); adults occur all winter in South Florida; in the Gainesville area the only records are fall (18 Sept. to 18 Nov.).

Eurema lisa Boisduval and Le Conte (Pieridae) occurs northward to Quebec and Ontario. Neither adults nor pupae seem to survive the winters north of 40° (Howe, 1975). When adults appear in Missouri in late spring, they are "invariably ragged, faded and torn, indicating that

they may have flown into the area from the south. In the absence of near freezing temperatures (such as in [south] Florida) there are continuous broods" (Howe, 1975:372). All records during this study were in fall (3 Sept.–26 Oct.).

The information above is compatible with the hypothesis that each of the eight species detected moving southward through Gainesville in the fall breeds farther north than it overwinters. Except for *P. coenis* and *P. sennae*, nothing conflicts with and some data support the more extreme hypothesis that overwintering occurs no farther north than peninsular Florida. Either hypothesis requires northward flights in spring or early summer. The Malaise traps detected such flights only for *P. coenia* and *A. vanillae*. Williams (1958) reported direct observations of northward spring flights for three of the eight species: *P. sennae* (Ala.); *A. vanillae* (Fla.) and perhaps *U. proteus* (Fla.). (The other five species are less conspicuous and/or more difficult to identify on the wing.) The lack of trapping evidence for northward flights in six of the species might be attributed to fewer individuals taking part or to different patterns of flight (e.g. slower and less unidirectional, Nielson, 1960; or above 2 m).

The flights through Gainesville that were documented by Malaise traps differ significantly from the migratory flights of most insects (Johnson, 1969) and perhaps of most butterflies (Baker, 1968a, 1968b, 1969).

Johnson (1969) emphasized that most long-distance flights by insects are above the *boundary layer*—the layer of air near the ground in which the air movement is less than the insect's air speed—and cites instances where long-range dispersal of butterflies may be primarily wind determined. The thickness of the boundary layer depends on air speed of the insect, speed of the wind, and degree to which the roughness of terrain or vegetation slows the air near the ground. The butterflies and skippers observed during this study and captured in the Malaise traps were generally, probably always, flying within their boundary layers. When the wind was blowing in the direction of flight, the migrants flew higher, and when the wind was blowing counter to the direction of flight, they flew lower, but butterflies and skippers were never seen flying at wind speeds greater than their air speeds. When the flights were greatest, the winds were light and variable. Air speeds for *A. vanillae* average 18 km/h (Arbogast, 1966) while those for *U. proteus*, *P. coenia*, and *P. sennae* average 23, 18, and 20 km/h respectively (Correale and Crocker, 1976; Balciunas and Knopf, 1977). Flight heights for the same four species (over open ground) are generally 0.2–2.0 m (Arbogast, 1966; Edwards and Richmond, 1977).

Baker (1968c, 1968b, 1969) concluded that at least six and possibly

eight of nine species of British migratory butterflies for which he had data orient by means of the sun but do not compensate for its movements. In other words, mean flight direction during the day changes approximately $15^\circ/\text{hr}$. Such is not the case for the four species that have been studied at Gainesville. Arbogast (1966) found no significant shift in flight direction with time of day for *A. vanillae* nor did Balciunas and Knopf (1977) for *U. proteus*. I have similar unpublished observations for *P. coenia* and *P. sennae*. By what means these insects maintain approximately the same compass direction at all times of day is unknown. Two hypotheses seem especially worth testing: time-compensated sun orientation (e.g. Frisch, 1974) and orientation by means of the earth's magnetic field (e.g. Lindauer, 1977). Malaise-type traps could be used to capture large numbers of migrants for clock-shifting experiments or for testing with simulated suns or magnetic fields.

Since the Malaise traps operated continuously and collected small, plain insects as well as large, showy ones, they had the potential of detecting migratory flights of species that were rare, inconspicuous, or difficult to identify on the wing. Four of the eight species detected migrating (Table 1) were such species: *P. ocola*, *L. accius*, *U. dorantes*, and *E. lisa*. The methods of trapping and of analyzing the catches could have detected boundary-layer migratory flights of species in other insect groups—for example, moths, flies, wasps, and dragonflies. None was detected although low-altitude directional flights of such insects have been observed elsewhere (Williams, 1958). Species of these groups either did not migrate through Gainesville at altitudes below 2 m or they migrated in numbers too small to be detected by one or two 6-m Malaise traps.

The Method

The estimated net displacements northward and southward in Table 1 and Fig. 3 should be evaluated as to precision (repeatability) and accuracy (correspondence to true value). Different N-S traps at the same site or at sites 15 km apart gave estimates of net displacement that were so similar that the traps could not be proved different with the number of paired observations available (Table 3). The only apparent problem with precision is variation in trapping efficiency attributable to wind direction (see above).

Evaluating accuracy depends on comparing the values obtained with Malaise traps with values obtained by using other methods. Since no other method of continuous or automatic monitoring has been developed, the only comparisons that can be made are with direct, visual observations. The only such observations made were brief and not intended to check

TABLE 3. Comparisons of effectiveness of two N-S traps in detecting net displacement when they were 43 m apart at the same site (Green Acres) and when they were at two sites 15 km apart.

Comparison Species (season)	Number of Observations ⁴	Net Numbers ¹		Accept H ₀ ³
		Trap A $\bar{x} \pm \text{SD}^2$	Trap B $\bar{x} \pm \text{SD}^2$	
Same site				
<i>U. proteus</i> (fall)	16	15.2 ± 20.4	11.2 ± 11.4	yes
Different sites				
<i>U. proteus</i> (fall)	11	34.9 ± 20.4	42.4 ± 25.8	yes
<i>P. coenia</i> (spring)	5	7.6 ± 1.8	5.4 ± 2.8	yes

¹ In fall, number intercepted flying southward less number intercepted flying northward; in spring, the reverse.

² Standard deviation is used here merely as a measure of variation; distribution of catches was not assumed to be normal.

³ The null hypothesis (H₀) was that traps A and B were sampling the same population with equal effectiveness. The Wilcoxon Matched-Pairs Signed-Ranks test at P = 0.05 was used (Siegel, 1956).

⁴ Number of days (*U. proteus*) or weeks (*P. coenia*) during which both traps were operative and at least one individual was caught. For the observations of *P. coenia* no period shorter than a week could be used because trap-service dates at the two sites generally coincided but once per week.

the accuracy of trapping estimates; however, the two methods of estimation agree well enough (Table 4) to suggest that the error in trapping estimates of the four species directly observed is decidedly less than an order of magnitude. For *U. proteus* this evaluation has an element of circularity because direct observation of that species yielded the 10% trapping efficiency that is incorporated into the formula for estimating net displacement from trapping results.

Advantages of using Malaise traps to study migration within the boundary layer include the following: (1) Continual monitoring is practical. (2) Sensitivity is great enough to detect small-scale flights. (3) Cost is low enough to permit replication or extensive monitoring. (4) Acceptable precision and accuracy are attainable. (5) Capture of individuals permits positive identification and determination of sex and mating status. (6) With modified heads, traps could catch large numbers of individuals for mark-release studies of destination of migrants or for studies of means of orientation.

The following are important limitations to using Malaise traps in studying insect migration (though some can be overcome by modifying the trap design): (1) Only flights near the ground can be monitored (modified traps could be suspended from tethered weather balloons). (2) Traps are damaged by severe storms (hardware cloth or woven wire could be substituted for the polyester mosquito netting). (3) Information as to flight direction is crude: $\pm 90^\circ$ (traps with barriers every 90° or 45° could be built). (4) Weather factors, such as wind direction, will affect

TABLE 4. Comparison of estimates of numbers flying southward across a 1 m WSW-ENE line, per hour, by direct observation and by trapping at Green Acres site.

Species	Method of Estimate	Date and Time of Direct Observation		
		11 Oct. 1975 1552-1622	12 Oct. 1975 1248-1318	26 Oct. 1975 1229-1252
<i>U. proteus</i>	Direct ¹	20.5	27.7	16.0
	Trapping ²	15.0	23.2	7.7
<i>P. coenia</i>	Direct ³	1.3	1.6	0.9
	Trapping ²	3.5	5.4	0.4
<i>P. sennae</i>	Direct ³	1.8	0.4	0.5
	Trapping ²	0.7	2.1	0.4
<i>A. vanillae</i>	Direct ³	0.3	0.4	0.7
	Trapping ²	0.5	0.5	0.2

¹ Based on counting individuals crossing a 6 m WSW-ENE line.

² Based on the day's catch of individuals in N-S traps with improved heads. Trapping efficiency was assumed to be 10% and flight activity was assumed to be spread evenly over 7 hrs: indiv/m/hr = $10N/w/7$, where N is number trapped flying southward and w is width of trap(s) (6 m for 11 and 12 Oct.; 12 m for 26 Oct.).

³ Based on counting individuals crossing a 15 m WSW-ENE line.

height of flight and hence trapping efficiency. (5) An insect entering the trap from one direction may have a greater probability of being captured than one entering from another direction. For example once an insect has struck the barrier, it may fly toward the brightest light—often the sun to the south. If the direction of attempted escape is south, an insect on the south side of the barrier would be more likely to escape than one on the north side of the barrier. If this bias occurs, it is apparently slight: For example, *Hylephila phyleus* (Drury), (Hesperiinae), was caught in larger numbers than any other nonmigratory skipper or butterfly. Of 198 individuals caught in N-S traps, 111 were captured on the north side and 87 on the south side. A chi square test reveals no significant bias ($P > 0.05$).

ACKNOWLEDGMENTS

I thank Dana Focks for creating the traps and helping tend them, Dave Nickle for processing many of the collections, Dale Habeck for help with techniques, Earl Horner of the Agronomy Department for permitting use of Green Acres, Tom Emmel for help with identification and literature, and James Lloyd, James Nation, and Boyce Drummond for criticizing the manuscript.

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HYBRIDS BETWEEN *CALLOSAMIA* AND *SAMIA* (SATURNIIDAE)

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ABSTRACT. Several crosses between *Callosamia promethea* and *Samia cynthia* were made between 1900 and 1910, and the hybrid specimens are now in museums. Recently, the cross *C. angulifera* ♂ × *S. cynthia* ♀ was made, yielding four F₁ adult males. Egg hatching rate was high in this cross. The hybrid larvae, cocoons, adults, and male genitalia all were intermediate between those of the parent species. Other intergeneric crosses involving these moths produced no adults, but limited information was obtained from such attempts. The Nearctic *Callosamia* is closely related to the Asiatic *Samia*, perhaps even more closely than to the Nearctic *Hyalophora*. The chromosome numbers in these genera are all quite different; thus, crosses rarely produce ova which hatch. Ecological and morphological differences between the genera suggest that they do not cross in nature.

Between 1900 and 1910 a few lepidopterists succeeded in rearing crosses between *Callosamia promethea* (Drury) and *Samia cynthia* (Drury). Miss C. G. Soule published her results several times (Soule, 1902, 1906, and 1907) as did Joutel (1907). Some of the hybrid larvae reared by Soule were figured by Packard (1914) but apparently Ferguson (1972) was first to illustrate one of the impressively intermediate adults of such crosses. Packard (1914) also cited unpublished remarks from Herman Strecker stating that these hybrids occur in nature. However, considering that Strecker's scant descriptions do not coincide with the artificial hybrids, these remarks should perhaps be discounted. Furthermore, I indicate later in this paper why such crosses are not likely to occur in nature.

I have seen hybrids from these early workers in the United States National Museum and the American Museum of Natural History. Most of these are obviously true hybrids such as the male of the cross *S. cynthia* ♂ × *C. promethea* ♀ figured in color by Ferguson (1972). However, others appear to be pure *S. cynthia* such as the other "hybrid" which Ferguson illustrates (a female stated to be of the cross *C. promethea* ♂ × *S. cynthia* ♀). I believe these latter specimens are pure *S. cynthia* because it is unlikely that progeny of an intergeneric cross could look so much like one parent species (in larval, cocoon, and adult traits) and bear no resemblance to the other. Indeed, Joutel (1907) and Soule (1906) reveal that they sometimes remated females to males of their own species in order to initiate oviposition. Future workers who find this practice

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necessary might try remating females to males which have been artificially sterilized beforehand. The purpose of this paper is to report results of similar intergeneric crosses not previously published.

Callosamia angulifera ♂ × *Samia cynthia* ♀

Using hand-pairing and rearing methods which I have described in an earlier paper (Peigler, 1977), I obtained two fertile matings of this cross and adults from one of these crosses. The females oviposited freely so that remating to males of *S. cynthia* was unnecessary. One of these crosses employed a male *C. angulifera* (Walker) from Clemson, South Carolina and a female *S. cynthia* from Brooklyn, New York. Of 248 ova laid, only four larvae eclosed and these died during the first day.

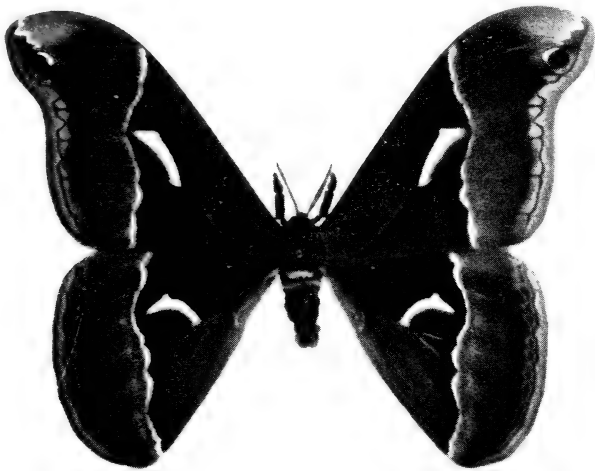
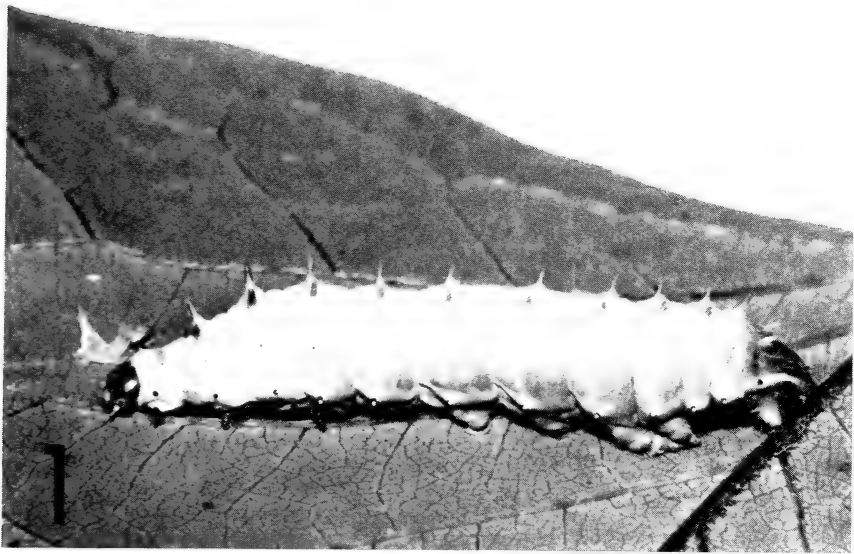
Another male *C. angulifera* from Clemson was mated to a female *S. cynthia* from New Haven, Connecticut. This time the percent hatch was very high and the larvae were reared on tuliptree (*Liriodendron tulipifera* L.), the food of the father species. Mature larvae were offered ailanthus (*Ailanthus altissima* (Mill.) Swingle), the food of the mother species, and refused it completely. All the larvae were intermediate and exhibited very little variation, but Soule (1902) reported a "*cynthia* form" and a "*promethea* form" in one of her broods. Although disease killed many larvae throughout the rearing, 14 cocoons were obtained. Of the 14 cocoons, ten pupated, and ultimately four adult males were secured, the others dying as pupae. Physiological problems were noted with the pupal stage. Two individuals remained green contracted larvae (pre-pupae) in cocoons for over 13 days before finally pupating. Three males emerged in the autumn, a full year after pupation, and the fourth in the spring after the second winter. In late May after the second winter, the two remaining pupae were injected with 12 µg of α-ecdysone in an attempt to break diapause but they died shortly afterwards.

Descriptions below are based on larvae and pupae preserved in ethyl alcohol of the hybrids and pure species except the description of the mature larva which was written with living specimens before me of the hybrids and mature larvae of *S. cynthia* and *C. angulifera*.

First instar. Head like *C. angulifera* with a light frontal band. Markings on integument of thoracic and abdominal segments like *S. cynthia* but weaker. No stripes as in *C. angulifera*. Scoli on all segments basically intermediate, tending toward *S. cynthia*. Lateral dark patches on all prolegs intermediate.

Second instar. Color deep yellow as in both parent species. Evidence of both the striping as in *C. angulifera* and the mottling in *S. cynthia*. Scoli dark and more like *S. cynthia*.

Third instar. Greenish-yellow with darker yellow head and prolegs. Still more like *S. cynthia* with mottled integument. Frontal band no longer present, which would be in pure *C. angulifera* of the same instar.



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Fig. 1. Mature larva of *C. angulifera* ♂ × *S. cynthia* ♀ on tuliptree. (Photo by G. R. Carner.)

Fig. 2. Adult male of *C. angulifera* ♂ × *S. cynthia* ♀. (Photo by E. V. Gage.)

Fourth instar. Very similar to the fifth instar but with whitish powder covering integument.

Fifth instar (Fig. 1). Color lighter than *C. angulifera* but waxy white powder minimal or absent. Head like both parents; the heads of *C. angulifera* and *S. cynthia* are much alike in size, color and shape. Yellow on top of prothoracic segment as in *S. cynthia* (absent in *C. angulifera*). Thoracic legs darker green-yellow than in *C. angulifera*. Lateral stripe concolorous with body (like *S. cynthia*) or slightly yellowish (very yellow in *C. angulifera*). No black spots on the integument as in *S. cynthia* but never in *Callosamia*. Spiracles light blue. Prolegs mostly like *C. angulifera* but with some yellow as in *S. cynthia*. Anal claspers without blue of *S. cynthia*; the black ring of *C. angulifera* reduced to a posterior black stripe. Anal plate with two lateral black spots of some *C. angulifera* but lacking the black streak between. Dorsal scoli (tubercles) of meso- and metathoracic segments orange with yellow-green base, longer than in *C. angulifera*. Dorsal scoli on first abdominal segment orange or yellowish-orange on tip, higher yellow-green base. All other dorsal scoli yellow, one greenish larger one on eleventh segment. Subdorsal scoli small, raised, pointed blue tubercles; in some individuals the ones on third and fourth segments with black at base. Subspiracular tubercles all small and blue with black bases; the one on first segment a black dot as in *C. angulifera*. Thoracic segments each with a subventral black button as in both parent species.

Pupa. Anal angles of forewings lying on fourth abdominal segment as in *Callosamia*. The maxillary area between antennal covers much more like *S. cynthia* (see Mosher, 1916).

Cocoon. About two-thirds with attachments to stem. Intermediate, but variable shapes tending to *S. cynthia* and dark brown coloration quite like *C. angulifera*.

Male (Fig. 2). Antennae and frons like *C. angulifera* in size and coloration. Scaling on body intermediate in color. No dorsal white tufts on abdomen but lighter scaling in first two abdominal tergites as in *S. cynthia*. Legs without white scaling. Antemedian line intermediate. Postmedian line with maroon replacing light pink in *S. cynthia* and golden suffusion in *C. angulifera*. Ground color and submarginal ornamentation of forewing and hindwing all intermediate. Apical black patch larger like *C. angulifera*. Discal mark in each wing more like *S. cynthia* but with an anterior tooth suggesting *C. angulifera*. Overall coloration of underside much closer to *C. angulifera*.

Male genitalia (Fig. 3). Intermediate in general but more like *C. angulifera*. Uncus larger as in *S. cynthia*, and saccular lobe of valve less produced as in *S. cynthia*. Median lobe like *S. cynthia* but wide costal lobe like *C. angulifera*, with no evidence of the indentation which *S. cynthia* so clearly has in the costal lobe. Anellus more like *S. cynthia* but transtilla (gnathos) weaker as in *C. angulifera*. Aedeagus shorter than either parent species and intermediate in width. Only one hybrid dissection studied.

Unfortunately, no attempt was made to test fertility of these F_1 males. Of the four males obtained, one is in the collection of Dr. Claude Lemaire of France, another in the Los Angeles County Museum, and two are in my collection.

Additional Crosses

Limited information is available on other intergeneric crosses and it seems appropriate to report it here. These include *Callosamia securifera* (Maassen) ♂ × *Samia cynthia* ♀ and *Callosamia promethea* ♂ × *Hyalophora cecropia* (L.) ♀. None of these resulted in adult imagines.

Using a male of *C. securifera* from Berkeley County, South Carolina

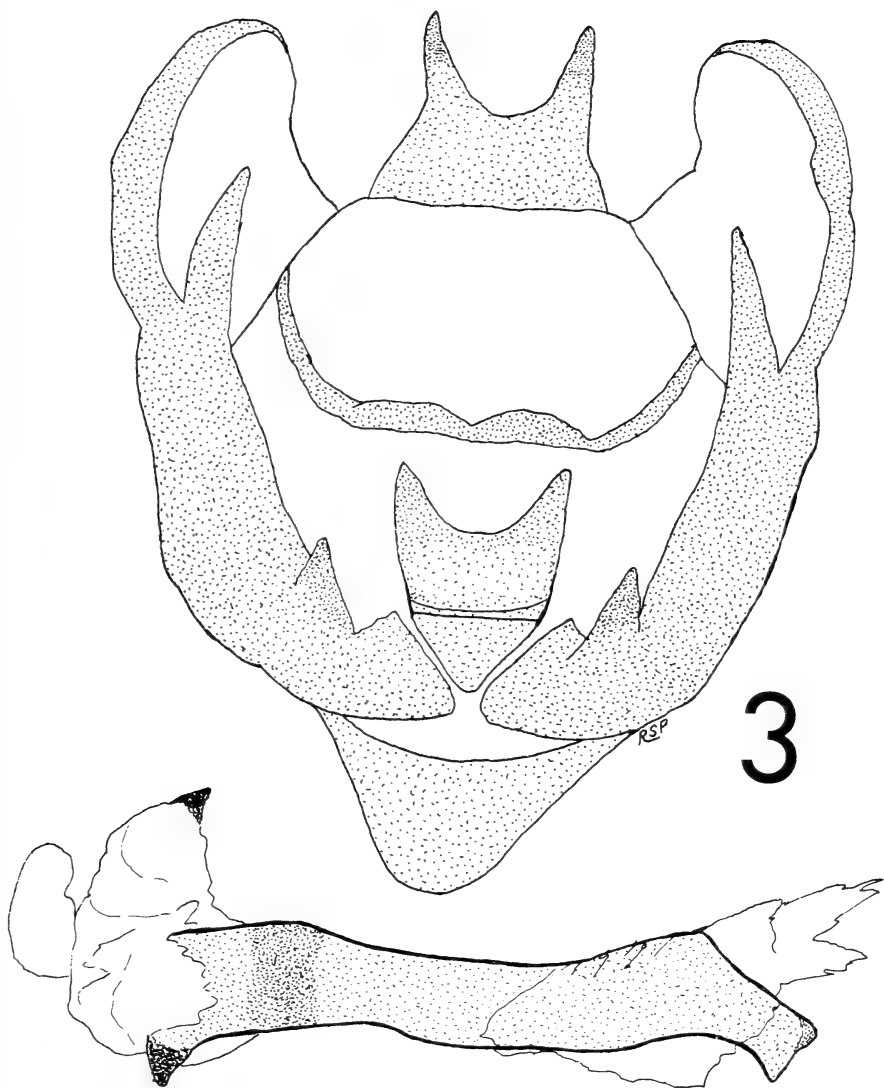


Fig. 3. Male genitalia of *C. angulifera* ♂ × *S. cynthia* ♀.

and a female of *S. cynthia* from Paris, 58 ova were secured. Only six ova hatched but most other embryos reached full development even though they failed to hatch. This became apparent when viewing the batch of ova after they had been stored in ethyl alcohol. The six larvae were offered tuliptree but were very weak and expired within a few hours.

They had banded heads and dorsal segmental stripes as in pure *C. securifera*, but the scoli were more like *S. cynthia*.

Mr. Laurence R. Rupert of Sardinia, New York very kindly provided information on a cross he made between a male *C. promethea* and a female *H. cecropia* over 60 years ago:

"... After holding the abdomens together for a time, I succeeded in inducing a mating. The *cecropia* produced a good number of eggs, but only 8 or 9 hatched. The young larvae at first resembled those of *cecropia*, but as time went on they grew more and more to resemble those of *promethea*. I fed them lilac [*Syringa vulgaris* L.] since I knew that was a favorite food of both parents.

Only two larvae survived to make cocoons, and the two cocoons were very different. One was quite hard, resembling in shape a very small *cecropia* cocoon of the hard non-puffy type. The other was irregular in shape with a strip of silk along a stem, like a *promethea* cocoon, but weaker. No moth emerged from either, and I never bothered to open the cocoons to see whether the larvae pupated."

The same season during which I succeeded with the *C. angulifera* ♂ × *S. cynthia* ♀ hybrids, numerous other matings were made which resulted in no eclosion of ova. Adults of *Samia cynthia*, *S. canningii* (Hutton), *H. cecropia*, and hybrids and all three species of *Callosamia* were used in various combinations. In general, the male genitalia of *C. promethea* and *H. cecropia* are so large that females of other species are often killed by mating with them. The genitalia of other *Callosamia* males are very compatible with *Samia* females and such crosses should be tried whenever possible. I have been unable to accomplish hand-pairings in which the male was *S. cynthia*.

DISCUSSION

The value of hybridization as a tool in elucidating phylogeny has been well documented by Hubbs (1967). The fact that *Samia* is Asiatic and *Callosamia* is Nearctic may have caused earlier authors to overlook the affinities of the two groups. The close relationship based on morphological studies has been pointed out by Lemaire & Peigler (1978). Additionally, tuliptree, the main food of *Callosamia*, is an excellent food for pure *S. cynthia*, the larvae growing much faster than they would on other substitutes for their preferred host, ailanthus (pers. obs.). This becomes even more significant when one finds that larvae of the genus *Hyalophora*, considered closest to *Callosamia*, fail to survive on tuliptree (Scarbrough et al., 1974). Intrageneric introgression sometimes proves to be advantageous to populations of organisms, but one can hardly see any possible advantage in intergeneric hybridization. Therefore, some specialized biochemical isolation mechanism may be in effect for the two sympatric genera of North America, not shared by the Asiatic *Samia*.

The chromosome number of *C. promethea* is 19, that of the species of *Hyalophora* is 31, and the various species of *Samia* is 13 and 14 (Robinson, 1971). Thus the pairing of sex chromosomes and autosomes possibly becomes critical when hybridizing these related genera, and this may explain several results such as lack of females (the heterogametic sex in Lepidoptera) in many hybrid broods, the rarity with which ova hatch in such crosses, and the different results sometimes obtained with reciprocal crosses (see Peigler, 1977).

The question arises as to whether such crosses ever occur in nature so that a collector might encounter such wild hybrids. The larger genitalia of *C. promethea* and its diurnal mating behavior argue against the possibility of this species mating with *S. cynthia*. The genitalia and mating times of *C. angulifera* and *S. cynthia* are much more compatible, but a pheromone difference exists wherein females are unlikely to attract males of the other species. Also, *S. cynthia* exists almost exclusively in large cities where *C. angulifera* populations are quite unlikely to occur with any regularity, if at all. Even after being in North America over 100 years, *S. cynthia* still appears to be predominantly on *ailanthus* in urban areas.

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RHOPALOCERA OF WEST VIRGINIA¹

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ABSTRACT. A current summary of the records of the butterflies (Rhopalocera) of West Virginia is given. Published records, including references to the state's fauna discussed in William Henry Edwards' *Butterflies of North America*, provided distribution data for 71 species. These records are indexed in order that the sources of information may be easily traced. Extensive collecting by the authors from 1972 to 1977, records of museum specimens and contributions of data by other collectors resulted in records of 40 additional species, making a total of 111 butterflies now known from West Virginia. A listing of 34 species which are expected to occur in the state is also included.

The distribution of Rhopalocera has been of continuous concern to lepidopterists. Within the past century, many state and national checklists have been compiled. This is an important step toward monitoring population levels and range changes of species. Recently, these lists have become valuable to conservationists attempting to define endangered species. Without the basic information these checklists provide, few studies relating to other aspects of Rhopalocera can be undertaken.

While butterflies of most of the states have already been studied, the fauna of West Virginia has, until now, been neglected. Faunal studies of the states bordering West Virginia allude to species which should occur here. With regard to West Virginia, Field et al. (1974) list 38 publications, 34 of which were written by W. H. Edwards. The information in the Edwards publications is best summarized in his three volumes of *Butterflies of North America* (1868, 1884 and 1897). Edwards mentioned 35 species with specific reference to West Virginia in his voluminous work. Many of these 35 species were taken at Coalburg in Kanawha County. Brooks (1905) listed 24 species in the Cranberry River area. Additional published records of West Virginia butterflies not given by Field et al. (1974) include those of Holland (1913), Burns (1964), Clench (1972), Irwin (1972) and those by contributors to the Field Summaries in the Lepidopterists' News and the News of Lepidopterists' Society: Allen (1976), Boscoe (1976), Butler (1976), Drees (1974, 1976), Jensen (1976), Lavy (1974), Nicolay (1953), Parshall (1974), Preston (1951) and Showalter (1975). These publications provide distributional data for 71 species of butterflies which occur in West Virginia. Clark and Clark

¹ Published with the approval of the Director of the West Virginia University Experiment Station Paper No. 1500.

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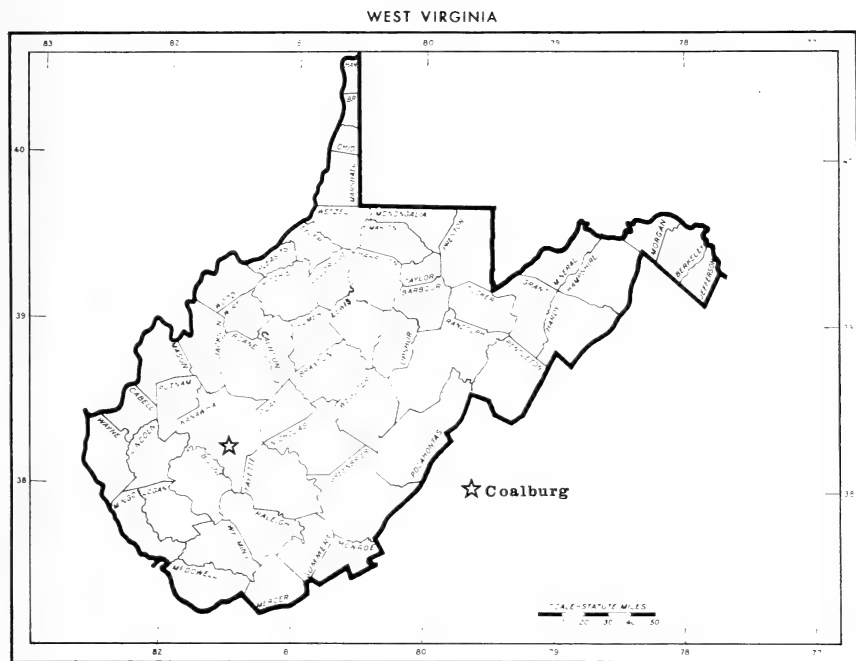


Fig. 1. Map of West Virginia with county designations. The site of Coalburg in Kanawha County was the location of many of the W. H. Edwards state records.

(1951) further noted that "a few early records from 'Virginia' refer to West Virginia which was part of Virginia until 1863."

Intensive collection throughout the state for the past five years by the authors and contributions of collection records by T. J. Allen, J. W. Amrine, A. E. Cole, C. V. Covell, Jr., J. M. Flanery, P. Francis, J. D. Hacker, R. Lavy, R. H. Lindsey, T. L. Mason, A. H. Showalter, R. E. Stanford and M. D. Taylor have added to the construction of a more complete statewide list. Data from these sources and data obtained by the authors from Carnegie Museum of Natural History, National Museum of Natural History (USNM), West Virginia Department of Agriculture, and West Virginia University Entomology Department collections have resulted in 40 previously unpublished state records. Thus, at present, a total of 111 species is known from West Virginia.

Specimens in the possession of the authors in the West Virginia University insect collection were identified, and the more difficult groups were confirmed by J. M. Burns, USNM (Hesperiidae); H. K. Clench, Carnegie Museum of Natural History (Lycaenidae and Nymphalidae); and W. D. Field, USNM (Lycaenidae). Advice from these sources as well

as that from H. A. Freeman and A. B. Klots has not only enhanced the accuracy of this paper, but has made valuable contributions to the listing of 34 additional species expected to be found in West Virginia. All of the species in the following list have already been reported from one or more of the bordering states (Covell, 1967, 1974; Covell and Straley, 1973; Fales, 1974; Clench, unpublished; Wood and Gottschalk, 1942).

Hesperiidae: *Lerodea eufala* (Edwards), *Atrytonopsis hiana hiana* (Scudder), *Euphyes dion dion* (Edwards), *E. dukesi* (Lindsey), *E. conspicua conspicua* (Edwards), *Poanes massasoit massasoit* (Scudder), *P. viator* (Edwards), *Polites vibex vibex* (Geyer), *Hesperia metea* Scudder, *Thymelicus lineola* (Ochsenheimer), *Lerema accius* (Smith), *Erynnis persius persius* (Scudder), *E. zarucco zarucco* (Lucas), and perhaps *Panoquina ocula* (Edwards), *Calpodus ethlius* (Stoll), *Poanes yehl* (Skinner), *Problema byssus* (Edwards), *Hesperia attalus attalus* (Edwards), *Thorybes confusus* Bell and *Urbanus proteus* (Linnaeus).

Pieridae: *Colias cesonia* (Stoll) and *Nathalis iole* Boisduval.

Riodinidae: *Calephelis muticum* McAlpine.

Lycaenidae: *Satyrium caryaevorus* (McDunnough), *Euristrymon ontario ontario* (Edwards), and perhaps *Satyrium acadica acadica* (Edwards), *Callophrys irus irus* (Godart), *Panthiades m-album* (Boisduval and LeConte) and *Lycaeides melissa samuelis* Nabokov.

Nymphalidae: *Anaea andria andria* Scudder, *Nymphalis vau-album* (Denis and Schiffermüller) and *Chlosyne harrisii harrisii* (Scudder).

Satyridae: Perhaps *Lethe creola* (Skinner) and *Euptychia areolata areolata* (Smith).

The following list of the Rhopalocera of West Virginia follows basically the sequence and nomenclature of Dos Passos (1964) and his revisions (1969, 1970), but includes further changes and additions by Cardé et al. (1970), Clench (1972, 1975), Field (1971), Freeman (1973) and Howe (1975). County records and extreme collecting dates for more than 1340 specimens are included. Location of counties is shown on the West Virginia map (Fig. 1). Index numbers given in parentheses in the species list refer to notes at the end. Counties with index numbers do not necessarily represent single collection records. The authors would greatly appreciate any corrections or additional data for future revision of this initial summary.

Hesperiidae

Amblyscirtes samoset (Scudder)—Monongalia, Pocahontas (2); V-8.

A. vialis (Edwards)—Mineral, Monongalia; V-4 to 24.

Euphyes bimacula (Grote and Robinson)—Pendleton (11), Webster; VIII-5 to 8.

E. vestris metacometa (Harris)—Braxton, Pocahontas, Randolph; VI-30 to VII-10.

Poanes massasoit hughii Clark (5).

P. hobomok (Harris)—Barbour, Berkeley, Braxton, Brooke, Grant, Mineral, Monongalia, Pendleton, Pocahontas, Preston, Randolph; V-12 to VII-4.

P. zabulon (Boisduval and LeConte)—Monongalia, Ritchie (5, 12); V-20 to VII-18.

Atrytone delaware delaware (Edwards)—Monongalia, Pendleton (11); VII-22.

Atalopedes campestris (Boisduval)—(5), Calhoun, Putnam; IX-19 to X-11.

Pompeius verna verna (Edwards)—(10) Braxton, Fayette, Gilmer, Hampshire, Hardy, Mercer, Mineral, Monongalia, Pendleton, Pocahontas; VI-24 to VIII-10.

- Wallengrenia egeremet* (Scudder)—Berkeley, Braxton, Fayette, Mineral, Monongalia, Pendleton; VI-8 to VII-11.
- Polites coras* (Cramer)—Berkeley, Cabell, Grant, Mineral, Monongalia, Pendleton, Preston, Randolph, Webster, Wetzel; V-20 to IX-9.
- P. themistocles* (Latreille)—Cabell, Monongalia; V-23 to VIII-13.
- P. origenes origenes* (Fabricius)—Mineral, Putnam; VI-25 to IX-19.
- P. mystic* (Scudder)—Preston, Randolph, Webster; VI-5 to VII-8.
- Hesperia sassacus sassacus* Harris—Preston, Randolph; VI-5 to 19.
- H. leonardus* Harris—(5), Kanawha, Lewis; VIII-1 to 7.
- Hylephia phyleus* (Drury)—Kanawha, Lewis; VIII-22.
- Ancyloxypha numitor* (Fabricius)—Berkeley, Brooke, Gilmer, Grant, Mason, Monongalia, Preston; V-24 to IX-15.
- Nastra therminier* (Latreille)—Monongalia; VII-3.
- Pholisora catullus* (Fabricius)—Monongalia; VII-22.
- Pyrgus centaureae wyandot* (Edwards)—Hardy, Kanawha; IV-16.
- P. communis communis* (Grote)—Monongalia, Pendleton; VIII-25 to X-2.
- Erynnis icelus* (Scudder and Burgess)—Barbour, Berkeley, Fayette, Grant, Hampshire (1), Kanawha, McDowell, Mineral, Monongalia, Pendleton (11), Preston, Pocahontas (1), Summers, Tucker; IV-11 to VI-25.
- E. brizo brizo* (Boisduval and LeConte)—Hampshire (1), Kanawha, Monongalia (1), Pendleton (11); IV-22 to VI-2.
- E. lucilius lucilius* (Scudder and Burgess)—(1), Pendleton (11); V-5.
- E. baptisiae* (Forbes)—Berkeley; VIII-3.
- E. martialis* (Scudder)—Hampshire (1); V-29.
- E. horatius* (Scudder and Burgess)—Berkeley, Hampshire (1), Hardy, Upshur (1); V-7 to VIII-3.
- E. juvenalis juvenalis* (Fabricius)—Barbour, Grant, McDowell, Hampshire (1), Monongalia (1), Pendleton (11), Pocahontas (1), Preston, Summers, Tucker, Webster; IV-15 to VIII-3.
- Staphylus mazans hayhurstii* (Edwards)—(5).
- Thorybes bathyllus* (Smith)—Mineral, Monongalia, Preston; VI-27 to VII-13.
- T. pylades* (Scudder)—Gilmer, McDowell, Mineral; V-21 to 24.
- Achalarus lyciades* (Geyer)—(7), Kanawha, Lewis, Mineral; V-24 to VIII-7.
- Autochton cellus* (Boisduval and LeConte)—Kanawha (5); V-15.
- Epargyreus clarus clarus* (Cramer)—Barbour (15), Berkeley (15), Braxton (15), Fayette, Gilmer, Grant, Hardy, Kanawha, McDowell, Mercer, Mineral, Mingo, Monongalia, Pendleton (11), Preston, Wayne; V-7 to VIII-18.
- Papilionidae**
- Battus philenor philenor* (Linnaeus)—Barbour (15), Braxton, Boone, Greenbrier, Hardy, Marion, McDowell, Randolph, Summers, Wayne, Webster (3); IV-30 to X-4.
- Papilio polyxenes asterius* Stoll—Braxton, Fayette (15), Greenbrier, Kanawha, Lincoln, Monongalia, Pocahontas, Randolph; V-11 to IX-13.
- P. cressphontes cressphontes* Cramer—Jefferson (15), Monongalia; VII-3 to IX-1.
- P. glaucus glaucus* Linnaeus—Barbour, Berkeley, Boone, Braxton, Brooke, Clay, Fayette, Gilmer, Grant (15), Hardy, Kanawha (5), Marion, McDowell (15), Mercer, Mineral, Mingo, Monongalia (12), Preston, Putnam, Randolph, Summers (15), Tucker, Upshur, Wayne, Wetzel; IV-16 to IX-19.
- P. troilus troilus* Linnaeus—Barbour (15), Berkeley, Braxton, Boone, Cabell, Fayette, Gilmer (15), Grant (15), Hardy, Hampshire, Kanawha, Marion, McDowell (15), Mercer, Mineral, Mingo, Monongalia (12), Pocahontas, Preston, Randolph, Summers (15), Taylor, Wayne, Webster (3), Wetzel, Wood; IV-15 to IX-20.
- Graphium marcellus* (Cramer)—Boone, Braxton, Clay, Gilmer, Hampshire, Jack-

son, Kanawha (5), Monongalia, Randolph, Ritchie, Roane, Wayne, Webster (3); IV-21 to VIII-22.

Pieridae

Pieris protodice protodice Boisduval and LeConte—Kanawha (5), Webster (3); VII-2 to VIII.

P. virginiensis Edwards—Kanawha (5), Monongalia, Preston, Randolph (14), Tucker, Webster; IV-10 to V-14.

P. rapae (Linnaeus)—Berkeley, Braxton (15), Cabell, Grant, Hampshire, Mingo, Mineral, Monongalia, Preston, Randolph, Gilmer, Roane, Webster (3); III-19 to IX-12.

Colias eurytheme eurytheme Boisduval—Barbour, Berkeley, Braxton, Gilmer (15), Mercer, Mingo, Mineral, Monongalia, Pendleton, Pocahontas, Preston, Putnam, Randolph, Summers (15), Tucker, Wetzel; IV-27 to X-25.

C. philodice philodice Godart—Cabell, Braxton, Gilmer, Grant, Greenbrier, Hardy, Kanawha (5), Marion, Mason, McDowell, Mercer, Mingo, Mineral, Monongalia, Pocahontas, Preston, Putnam, Randolph, Summers (15), Tucker, Webster (3), Wetzel; V-20 to X-25.

C. interior interior Scudder—Randolph (13); V-7 to VII-31.

Phoebis sennae eubule (Linnaeus)—Upshur; VI-12.

Eurema lisa Boisduval and LeConte—Boone, Clay, Kanawha, Lewis, Monongalia; VIII-6 to X-9.

E. nicippe (Cramer)—Hardy, Kanawha, Lewis, Pendleton, Summers; VIII-6 to X-4.

Anthocaris midea Hübner—Greenbrier, Hampshire (12), Hardy, Kanawha (5), Mineral, Monongalia, Pendleton, Wood, Pocahontas; III-30 to V-30.

Euchloe olympia olympia (Edwards)—Hampshire (12), Hardy, Kanawha (5), Mineral; IV-16 to V-10.

Riodinidae

Calephelis virginiensis virginiensis (Guérin-Méneville)—(5).

C. borealis (Grote and Robinson)—Greenbrier (7), Hampshire, Monongalia; V-22 to VII-14.

Lycaenidae

Harkenclenus titus mopsus (Hübner)—Fayette, Mineral, Pendleton (11), Pocahontas, Randolph; VI-25 to VII-11.

Satyrrium liparops strigosa (Harris)—Fayette, Kanawha (5), Monongalia; VI-11 to VII-7.

S. calanus falacer (Godart)—Fayette, Mineral, Monongalia, Pendleton (10), Pocahontas; VI-25 to VII-19.

S. edwardsii (Saunders)—Greenbrier (14), Hampshire, Randolph; VII-12 to 26.

Calycopis cecrops (Fabricius)—Lewis, Nicholas; VII-8 to 14.

Callophrys polios polios Cook and Watson—Kanawha; IV-20.

C. henrici henrici (Grote and Robinson)—Hampshire, Kanawha; IV-25 to VII-28.

C. augustinus croesoides Scudder—Hampshire, Kanawha; IV-23 to V-3.

C. niphon niphon (Hübner)—Berkeley, Hampshire (12), Pendleton (11); V-5 to 28.

C. gryneus gryneus (Hübner)—Hampshire; IV-25 to V-10.

Strymon melinus humili (Harris)—Berkeley, Fayette, Greenbrier (14), Hardy, Mineral, Monongalia, Pendleton, Pocahontas, Randolph, Wood; VI-8 to IX-9.

Erora laeta (Edwards)—Cabell (6), Greenbrier (6), Kanawha (5, 6), Pendleton (11), Randolph; V-5 to VII-26.

Feniseca tarquinius tarquinius (Fabricius)—Mineral, Monongalia, Pendleton (11), Ritchie (12), Upshur, Webster (3); V-4 to IX-11.

Lycaena hyllus (Cramer)—Brooke, Monongalia; V-28 to IX-13.

L. phlaeas americana Harris—Barbour, Hampshire (12), Marion, Mason, Mineral,

Monongalia, Pendleton (11), Randolph, Taylor, Webster (3), Wood; V-11 to IX-30.

Everes comyntas comyntas (Godart)—Braxton, Grant, Greenbrier, Hardy, Mineral, Monongalia, Pocahontas, Preston, Randolph, Webster (3), Wetzel, Wood; V-2 to X-4.

Glaucopsyche lygdamus nittanyensis Chermock—Greenbrier, Kanawha (5), Ohio, Pendleton (11), Webster, Wood; V-5 to VI-15.

Celastrina argiolus pseudargiolus (Boisduval and LeConte)—Braxton, Boone, Cabell, Fayette, Gilmer, Grant, Greenbrier, Kanawha (5), McDowell, Mineral, Monongalia, Pendleton (11), Preston, Tucker, Wayne, Webster (3) Wetzel; III-30 to VIII-20.

C. ebenina Clench—Kanawha (4, 5), Pendleton (4); IV-17 to V-5.

Libytheidae

Libytheana bachmanii bachmanii (Kirtland)—Kanawha (5), Mercer (14), Monongalia, Randolph; VII-26 to IX-10.

Nymphalidae

Asterocampa celtis celtis (Boisduval and LeConte)—Kanawha, Mercer, Mineral (14), Monongalia, Morgan, Wayne, Wood (15); V-24 to IX-10.

A. clyton clyton (Boisduval and LeConte)—Mingo, Monongalia, Wayne; VII-17 to 27.

Limenitis arthemis arthemis (Drury)—Mineral (15).

L. arthemis astyanax (Fabricius)—Berkeley, Boone, Braxton (15), Gilmer (15), Grant, Greenbrier, Hardy, Marion, Mason, McDowell, Mercer, Mineral, Mingo, Monongalia, Pocahontas, Preston, Wayne, Webster (3), Wetzel; V-12 to X-9.

L. archippus archippus (Cramer)—Barbour (15), Boone, Braxton, Grant, Kanawha (5), Mason, McDowell (15), Mineral, Mingo, Monongalia, Randolph, Upshur, Webster (3), Wetzel, Wood; V-12 to IX-13.

Vanessa atalanta (Linnaeus)—Braxton (15), Hampshire (15), Marion, Monongalia, Pocahontas, Preston, Randolph, Tucker (15), Webster (3), Wetzel; V-1 to IX-20.

Cynthia virginicensis (Drury)—Barbour, Grant (15), Hampshire, Kanawha, McDowell, Mercer, Monongalia, Randolph, Tucker, Webster (3), Wood; V-7 to VIII-23.

C. cardui (Linnaeus)—Kanawha, Monongalia, Randolph; VII to VIII-30.

Junonia coenia (Hübner)—Grant, Randolph; IX.

Nymphalis milberti milberti (Godart)—Monongalia; X-21.

N. antiopa antiopa (Linnaeus)—Brooke (14), Greenbrier, Kanawha, Mineral, Monongalia, Pocahontas, Randolph, Tucker (15), Webster (3); III-10 to IX-4.

Polygonia interrogationis (Fabricius)—Barbour (15), Boone, Braxton, Gilmer (15), Grant, Kanawha (5), Marion, Mineral, Mingo, Randolph, Ritchie, Webster, Wetzel; IV-18 to IX-20.

Polygonia comma (Harris)—Barbour (15), Boone, Kanawha (5), Marion, McDowell (15), Monongalia, Monroe, Pendleton (11), Putnam, Randolph, Ritchie, Webster (3); V-5 to IX-20.

P. faunus faunus (Edwards)—Fayette (5), Webster (3); VIII.

P. progne (Cramer)—Cabell, Mercer, Mineral, Mingo, Monongalia, Pendleton, Wayne, Webster; VI-29 to X-14.

Chlosyne nycteis nycteis (Doubleday)—Boone, Braxton, Fayette, Grant, Hampshire, Hardy, McDowell, Mercer, Mineral (14), Monongalia, Pendleton, Ritchie, Wetzel; VI-18 to VIII-28.

C. gorgone carlota (Reakirt)—Kanawha; V-4.

Phyciodes tharos tharos (Drury)—Barbour, Berkeley, Boone, Cabell, Fayette, Greenbrier, Hampshire, Hardy, Kanawha (5), Marion, McDowell, Mineral, Mingo, Monongalia, Pocahontas, Preston, Putnam, Randolph, Summers, Wayne, Webster (3); IV-27 to IX-19.

- P. batesii* (Reakirt)—Kanawha; V-22 to 28.
Euphydryas phaeton (Drury)—Kanawha (5), Monongalia, Randolph (14); VI-1 to VII.
Boloria bellona bellona (Fabricius)—(10), Boone, Braxton, Greenbrier, Hampshire, Hardy, Jackson, Kanawha, Marion, Mineral, Monongalia, Pendleton (11), Pocahontas, Randolph, Webster (3), Wood; IV-18 to X-4.
B. selene myrina (Cramer)—Grant, Kanawha, Randolph; V-24 to VII.
Speyeria idalia (Drury)—Braxton, Clay, Hampshire, Lewis, Monongalia, Pendleton (11); VI-25 to IX-20.
S. atlantis atlantis (Edwards)—Monongalia, Pendleton (11), Randolph, Webster (3); VI-18 to IX-14.
S. diana (Cramer)—Boone (14), Fayette (5), Kanawha (5), Mercer, Webster (3); VI-13 to VII-2.
S. cybele cybele (Fabricius)—(10), Berkeley, Braxton, Cabell, Fayette, Gilmer, Grant, Greenbrier, Hardy, Kanawha (5), Marion, Mercer, Mineral, Mingo, Monongalia, Pendleton (11), Pocahontas, Preston, Putnam, Randolph, Summers, Wayne, Webster (3), Wetzel, Wood; V-24 to IX-19.
S. aphrodite aphrodite (Fabricius)—Fayette, Greenbrier, Hampshire, Kanawha (5), Monongalia, Pendleton (11), Preston, Pocahontas, Randolph, Tucker, Webster (3); VI-3 to X-9.
Euptoietia claudia (Cramer)—Berkeley, Monongalia, Pendleton (11), Preston, Randolph; VII-5 to IX-26.
- Danaidae
Danaus plexippus plexippus (Linnaeus)—Berkeley, Kanawha, Marion, Monongalia, Preston, Putnam, Randolph, Webster (3); V-28 to X-10.
- Satyridae
Lethe anthedon (Clark)—Berkeley, Boone, Gilmer, Grant, Greenbrier, Hampshire, Kanawha (5), Mason, McDowell, Mineral (14), Monongalia, Pendleton (11), Ritchie; V-24 to IX-12.
L. eurydice eurydice (Johansson)—Greenbrier, Kanawha (5); VI.
L. appalachia Chermock—Fayette, Greenbrier (14); VII-7 to VIII-13.
Euptychia gemma gemma (Hübner)—Boone, Kanawha (5, 8); VI-11 to VII-8.
E. hermes sosybius (Fabricius)—Boone; VI to VIII-24.
E. cymela cymela (Cramer)—Berkeley, Braxton, Brooke, Cabell, Fayette, Gilmer, Grant, Hancock, Hardy, Marion, Mason, McDowell, Mercer, Mineral, Mingo, Monongalia, Preston, Randolph, Wayne, Wetzel; IV-23 to VIII-13.
Cercyonis pegala pegala (Fabricius)—Barbour, Greenbrier, Hampshire, Hardy, Kanawha (5), Mercer, Mineral, Monongalia, Nicholas, Pendleton (11), Pocahontas, Randolph, Ritchie; VI-25 to IX-3.

ACKNOWLEDGMENTS

The authors would like to express gratitude to all of those persons cited above who have contributed their knowledge and their collection data, enabling this list to be the most complete and comprehensive summary of West Virginia Rhopalocera to date. We are especially grateful to H. K. Clench for suggestions and review of the manuscript.

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PHENOLOGY AND DIVERSITY OF A BUTTERFLY POPULATION IN SOUTHERN ARIZONA

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ABSTRACT. Butterfly populations were examined on the Santa Rita Experimental Range in southern Arizona in 1970-71. Thirty-nine species were recorded of which 14 were considered common and typical of the desert grassland community. Butterfly activity was noted in all months except November 1970 and January and February 1971. Peak species number and abundance were after the summer rains. Reduced abundance in spring 1971 was attributed to the dryness of the previous winter. Season lengths for the two years were similar. Univoltinism was 33% of the fauna in 1970 and 46% in 1971 and was a rainy season phenomenon. Species diversity (H') closely paralleled species counts.

It is widely recognized that flight periods of butterfly species in most areas are seasonal depending on several factors including emigration, voltinism, competition and tolerances of the component species to various environmental extremes. Differences in interspecific dates of emergence and lengths of flight periods and intraspecific synchrony result in changes in diversity throughout the total favorable season. Detailed studies of phenology and seasonal changes in diversity of butterfly populations in limited areas are nearly lacking (e.g., Emmel and Emmel 1962, 1963a, Shapiro 1975). I made observations on relative abundance and phenology of the butterflies in a small area in southern Arizona from May 1970 to November 1971, incidental to my studies of bird populations in the same area. In this paper I examine seasonal patterns of abundance and diversity of the butterflies and relate these, as possible, to environmental variables.

Study Area

All observations reported here were made on an area of approximately 50 ha. on the Santa Rita Experimental Range, elev. 1150 m, ca. 10 km SE of Sahuarita, Pima Co., Arizona. The study area, on the western slope of the Santa Rita Mountains, sloped slightly to the northwest and was dissected by several washes. This resulted in a heterogeneous habitat, typical of the surrounding area, with the larger trees and shrubs tending to be concentrated along water courses. The community including the study area was described as a desert-grassland biotic community (Lowe 1964) invaded by woody growth due mainly to protection from fire (Humphrey 1968). The dominant vegetation included mesquite (*Prosopis juliflora*), paloverde (*Cercidium microphyllum*), hackberry (*Celtis pallida*) and

TABLE 1. Temperature and rainfall at the Santa Rita Experimental Range weather station during the study period (rainfall data for May through August of both years are measurements made on the study area itself).

Mean monthly temperature (°C)											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov. Dec.
Mean	8.6	9.9	12.7	16.9	21.1	26.1	26.6	25.0	24.2	19.6	13.4 10.1
1970	-	-	10.4	14.0	22.3	26.6	27.2	24.8	21.8	16.3	* *
1971	9.9	10.1	14.2	15.7	19.2	25.1	26.9	23.2	22.6	15.6	- -

Monthly rainfall (cm)											
Mean	4.3	4.2	2.9	1.5	0.4	1.9	10.1	11.9	4.8	2.3	2.6 3.5
1970	-	-	5.9	0.7	0.0	2.5	9.5	2.4	9.6	1.2	0.1 0.3
1971	0.0	4.4	0.0	2.3	0.1	0.1	6.9	12.1	10.9	6.8	- -

* data not available.

cholla cacti (*Opuntia fulgida* and *O. spinosior*) with an understory of several grass species, some small woody bushes (especially *Acacia greggii*), succulents and herbs.

Rainfall and temperature for the study period are given in Table 1. Temperatures averaged near normal during the study. Rainfall was near normal through July 1970; August was drier than average and September wetter. The winter (October–March) of 1970–71 was one of the driest on record with rainfall for the period 13.8 cm below average. Thereafter, 1971 rainfall was about average.

Prosopis and *Acacia* began leafing and blooming in April. *Celtis* put out a few leaves at this time and a few grasses and annuals appeared. The summer rainy season initiated the annual growth of many grasses and herbs. *Celtis* and *Cercidium* came into full leaf at this time and additional leaf growth and flowering was seen on *Prosopis* and *Acacia*.

METHODS

Observations were made by counting all butterflies seen within 5 m of me as I walked through the area. Most actual counts were made over a 3–4 hour period between 0700 and 1300 on clear, windless days. Each of these days was considered as a standard observation day and relative abundance was expressed as number observed per day by 10 or 11 day periods. I made observations on other days of species composition which occasionally added to the species list for that time period. Specimens of most species observed were obtained from or near the study area.

RESULTS

Species Composition

A total of 39 species (32 in both 1970 and 1971) were recorded during this study (Table 2). Thirteen species were represented by no more than 2 observations in each of the two years. Nine additional species (*D. plexippus*, *E. claudia*, *S. melinus*, *H. isola*, *C. eurytheme*, *N. iole*, *P. protodice*, *P. communis*, *S. ceos*) were seen 2 or less times in one of the two years. Of the latter, all except *H. isola* and *P. protodice* were recorded in considerably greater numbers in the alternate year. Three species (*M. leda*, *E. amyntula*, *C. hippalus*) recorded several times in 1970 were absent in 1971. This leaves 14 species which I consider as typical and relatively common in this plant association. Nine of these (*A. leilia*, *D. chara*, *L. bachmanii*, *A. palmeri*, *L. marina*, *H. ceraunus*, *E. nicippee*, *P. catullus*, *E. funeralis*) are definitely resident in the area; the others (*D. gilippus*, *V. cardui*, *C. cesonia*, *P. sennae*, *B. philenor*) are

TABLE 2. Seasonal phenology of the butterfly fauna of the Santa Rita Experimental Range, Arizona (X indicates record for species on a day when numerical data were not collected).²

		April			May			June			July			Aug.			Sept.			Oct.			Nov.			
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
REGULAR SPECIES																										
<i>Danaus gilippus</i>	1970	-	-	-	-	-	1.3	0.5	1.7	0	1.5	2.3	7.7	7.7	3.6	1.6	0.7	2.0	0	0	0	0	0	0	0	0
<i>strigatus</i> (Bates)	1971	0	0	0	0	0	0.3	0	1.0	0	0.3	0	0.8	2.3	2.4	4.4	4.3	5.5	3.3	0	-	-	0	-	0	
<i>Asterocampa</i>	1970	-	-	-	-	-	6.0	7.5	5.0	6.0	4.5	17.3	14.5	5.8	17.0	16.0	11.3	13.3	4.0	0	0	0	0	0	0	
<i>leila</i> (Edwards)	1971	0	0	0	0.3	0	0.7	0.5	0	1.0	2.0	2.0	5.0	6.0	10.9	12.4	20.0	34.5	24.3	0	-	-	-	2.5	-	
<i>Dymasia chara</i>	1970	-	-	-	-	-	0	0	0	0	0	10.0	1.2	1.3	1.8	0.4	0.3	0	0	0	0	0	0	0	0	
<i>chara</i> (Edwards)	1971	0	0	0	0	0	0	0	0	0	0	0	0.2	4.3	0.5	1.2	2.2	0.5	0	-	-	-	0	-	0	
<i>Vanessa cardui</i>	1970	-	-	-	-	-	0	0	0	0	0.3	0.2	0.3	0.2	0.4	0.2	0	1.0	0	0	1.0	0	0	0	0	
(Linnaeus)	1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.3	1.0	-	-	1.0	-		
<i>Libytheana bachmanii</i>	1970	-	-	-	-	-	0	0	0	0	1.3	2.6	5.5	3.8	3.6	2.4	26.6	56.3	2.0	0	2.0	0	0	0	0	
<i>lorata</i> (Streker)	1971	0	0	0	0	0	0	0	0	0	0	0	0	2.2	0.8	7.5	13.3	13.5	8.7	1.0	-	-	-	0.5		
<i>Apodema palmeri</i>	1970	-	-	-	-	-	46.0	19.5	7.3	0	0	0	10.7	10.2	4.2	2.6	1.7	0	0	1.0	0	0	0	0	0	
(Edwards)	1971	0	0	0	0	0	0.3	0	1.0	0	0	0	0	0	1.4	2.0	2.6	1.0	X	0	-	-	0	-		
<i>Leptotes marina</i>	1970	-	-	-	-	-	9.7	55.5	12.3	0	0	1.3	1.2	0.3	0.4	0	0	0	0	0	0	0	0	0	0	
(Reakirt)	1971	0	1.5	1.5	2.5	2.5	7.0	9.5	9.0	0	0	0	0	0	0	0.6	0.2	0	0	0	-	-	0	-		
<i>Hemiargus ceraunus</i>	1970	-	-	-	-	-	3.3	18.5	12.3	1.0	0.5	0.3	1.3	1.0	0	0.4	0.3	0	0	0	1.0	0	0	0	0	
<i>gyas</i> (Edwards)	1971	0	0	0	0.3	0	0	0	2.0	0	0	0	0.2	0	0.5	1.4	X	0	0	0	-	-	0	-		
<i>Colias cesonia</i>	1970	-	-	-	-	-	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	
Stoll.	1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0	1.3	0	-	-	1.0	-		
<i>Phoebis sennae</i>	1970	-	-	-	-	-	X	0	0	0.3	0	0.2	1.7	2.8	3.4	1.4	0	0	0	0	0	0	0	0	0	
(Linnaeus)	1971	0	0	0	0	0	0	0	0	0	0	2.6	8.0	3.6	3.2	1.3	4.0	1.7	0	-	-	0	-	0		
<i>Eurema nicippe</i>	1970	-	-	-	-	-	X	0	0	0.5	0.8	5.5	5.3	8.8	8.8	2.8	1.7	1.0	0.3	0	1.0	0	0	0	0	
(Cramer)	1971	0	0	0	0	0	0	0	0	0	0	0.2	0	0.3	3.0	5.0	4.5	4.5	1.3	0	-	-	1.0	-		
<i>Battus philenor</i>	1970	-	-	-	-	-	0.7	0	0.7	0.8	0	1.5	2.5	1.0	6.8	11.0	2.7	1.7	1.0	0	0	0	0	0	0	
<i>philenor</i> (Linnaeus)	1971	0	1.0	0.5	0	0.5	0	0	0	0	0	0	0.4	0.7	2.1	2.8	6.7	9.0	4.0	0	-	-	0	-		
<i>Pholisora catullus</i>	1970	-	-	-	-	-	0	0	0	0	0	6.0	4.0	2.2	2.2	1.0	0	0	0	0	0	0	0	0	0	
(Fabricius)	1971	0	0	0	0	0	0	0	0	0	0	0	1.0	4.1	1.9	2.5	1.5	0	0	0	-	-	0	-		
<i>Erynnis funeralis</i>	1970	-	-	-	-	-	0	0.5	0	0	0.3	0.5	0	0.3	0.2	0	0.3	0	0	0	0	0	0	0	0	
(Scudder and Burgess)	1971	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0.2	0.2	0	0	0	-	-	0	-		
RARE RESIDENTS																										
<i>Ministrymon leda</i>	1970	-	-	-	-	-	0	0	0	0	0	0	0	1.7	0	0.4	0.3	0	0	0	0	0	0	0	0	
(Edwards)	1971	-	-	-	-	-	0.3	0.5	0.3	0	0	0.2	0.2	0.3	0.4	0	0	0	0	0	0	0	0	0	0	
<i>Strymon melinus</i>	1970	-	-	-	-	-	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	-	-	0	-	0	
<i>franki</i> Field	1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.2	0	0.3	0	0	0	0	0	0	0	
<i>Eveces amyntula</i>	1970	-	-	-	-	-	0	0	0.3	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	
(Boisduval)	1971	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	-	-	0	-	0	

TABLE 2. (Continued)

	April			May			June			July			Aug.			Sept.			Oct.			Nov.		
	1 2 3			1 2 3			1 2 3			1 2 3			1 2 3			1 2 3			1 2 3			1 2 3		
	1970	1971		1970	1971		1970	1971		1970	1971		1970	1971		1970	1971		1970	1971		1970	1971	
<i>Nathalis iole</i> Boisduval	-	-	-	-	0	0	0	0	0	0.3	0	0.5	0.2	0.8	2.2	1.0	0.3	0	0	0	0	0	0	
<i>Pyrgus communis</i> (Grote)	-	-	-	-	0	0	0	0	0	0	0	0.7	X	0.3	0.4	0.2	0	0.5	0	-	-	-	-	
<i>Staphylus ceos</i> (Edwards)	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	X	0	-	-	-	
<i>Cogita hippalus</i> (Edwards)	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0.2	0	0	0.3	0	0	0	0	0	
OTHER SPECIES ¹	-	-	-	-	0	0	0	0	0	0	1.5	1.0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL SPECIES	-	-	-	-	0	0	0.9	2.8	0.4	0.7	0	0	0	0	2.0	1.1	1.6	0	0.3	0	0	0	0	
NUMBER OF DAYS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NUMBER OF INDIVIDUALS/DAY	0	0	0	0	9	8	10	20	18	22	17	14	12	9	4	0	4	0	4	0	0	0	0	
	0	2	2	3	2	4	1	2	1	9	8	17	19	22	10	11	2	-	-	-	-	-	-	
	-	-	-	-	3	2	3	4	4	6	6	5	5	3	3	3	2	1	2	2	2	2	2	
	2	2	4	2	3	2	1	3	1	5	6	8	10	6	2	3	1	-	-	-	-	-	-	
	-	-	-	-	67.3	103.0	39.9	9.5	10.1	54.2	57.7	50.7	55.8	41.4	46.5	78.2	7.3	0	5.0	0	0	0	0	
	0	2.5	2.0	3.1	3.0	8.3	11.0	13.0	1.0	2.3	2.0	11.0	27.9	29.5	44.5	59.1	73.5	45.2	2.0	-	-	-	-	

¹ *Danaus plexippus* (Linnaeus), 1970; July, Sept., 1971; Aug., Sept., 1971; *Anaea atidea* (Guerin-Meneville), 1971; Sept., *Limenitis astyanax arizonensis* Edwards, 1971; March; *Texola elauda perse* (Edwards), 1971; Sept.; *Chlosyne lacinia crocale* (Edwards), 1970; July; *Euptoieta claudia* (Cramer), 1970; July, Aug.; *Vanessa atalanta* (Linnaeus), 1971; Aug.; *Vanessa annabella* (Field), 1970; Aug.; *Agraulis vanillae incarnata* (Riley), 1970; June, July; *Brephidium exilis* (Boisduval), 1970; June; *Hemiaris isola alce* (Edwards), 1970; July, 1971; June, Aug., Sept.; *Colias eurhyme* Boisduval, 1970; July, Aug., 1971; Aug., Sept.; *Pieris protodice* Boisduval and Leconte, 1970; June, July, 1971; Sept.; *Papilio polyxenes asterius* Stoll, 1970; July, 1971; Sept.; *Papilio cressiphontes* Cramer, 1971; Aug.; *Lerodea eufala* (Edwards), 1971; Aug., Sept.; *Hylephila phyleus* (Drury), 1971; Aug.; *Conacodes aurantiaca* (Hewitson), 1970; Sept., 1971; Aug.

² March (1971, 2, 2 days): no butterflies; March (1971, 3, 2 days): *Leptotes marina* 1.0, *Battus philenor* 2.5, other species 0.5; December (1970, 1, 1 day): *Nathalis iole* 3.0; December (1970, 2 and 3, 1 day each): no butterflies.

strong flying and wide ranging species which may or may not have used the area for reproduction.

All species recorded during this study were previously seen by me in other similar habitat and in other vegetation types in southern Arizona. No species not recorded on the study area were seen in adjacent areas. I thus consider the species list relatively complete.

The butterflies of the study area were representative of the Southeastern Arizona desert scrub habitat with considerable influence from the foothill canyon habitat as outlined by Brown (1965). All species seen on the study area were recorded in one or both of the above habitats by Brown (1965) except *V. annabella* and *E. amyntula*.

The Santa Rita Range butterfly fauna belong to 10 families (if Apaturidae and Heliconiidae are separated from Nymphalidae). Nymphalidae and Hesperidae were represented by the most species (8 each) followed by Lycaenidae (7) and Pieridae (6). Overall, the familial composition was more diverse than in many temperate communities (e.g., Emmel and Emmel 1963b) which often lack representatives of families with southern distribution (Heliconiidae) or with restricted larval food habits (Apaturidae and Libytheidae).

Apaturidae was by far the most abundant family in terms of individuals, due to the high abundance and long flight period of *A. leilia*. Lycaenidae and Libytheidae were next in individual abundance followed by Riodinidae and Pieridae. The two families with most species were represented by very few individuals. This distribution of individuals by family contrasts sharply with that in the Sierra Nevada of California where individual and species distribution was similar (Emmel and Emmel 1963b).

Phenology

Activity by adult butterflies was observed in all months except November 1970 and January and February 1971. The general pattern of activity was similar during the two years (Fig. 1). During spring and early summer there was a plateau in number of species which then increased rapidly to a peak in late summer before decreasing to a small number of species in fall. In both years, there were peaks of abundance in both spring and late summer with a period of nearly no activity between (Fig. 1). In 1970, the spring peak was much larger, and the summer peak began earlier and lasted longer than in 1971.

Phenology of the fauna as a whole appeared largely related to rainfall. Precipitation for winter 1969-70 was near average, and the spring population in 1970 was probably typical for the area. The very dry winter of

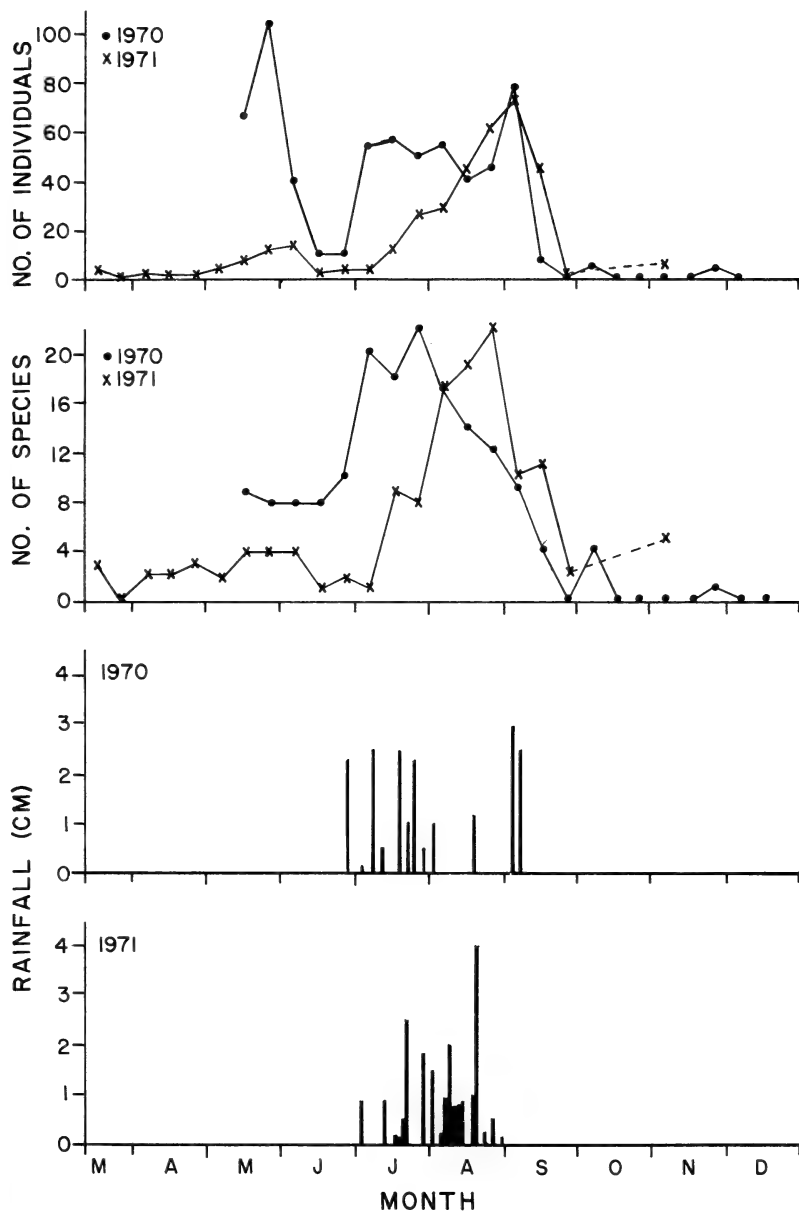


Fig. 1. Rainfall pattern (1 May-5 Sept.) and butterfly activity on the Santa Rita Experimental Range, Arizona, in 1970 and 1971.

1970-71 was probably responsible for the reduced diversity and abundance in spring 1971.

Differences in the overall summer flight period can be directly attributed to differences between the summer rainfall patterns (Fig. 1). The first heavy rain of 1970 was on 29 June and was followed by another similar rain less than a week later. These were sufficient to stimulate the summer growth of vegetation. Butterfly diversity and abundance increased rapidly after these rains but diversity decreased rapidly during the below average dryness of August. Abundance increased in September due mainly to the emergence of a large brood of *L. bachmanii*. Both diversity and abundance decreased rapidly in late September and early October.

The 1971 rainy season began on 2 July with a relatively light rain. The next rain did not occur until 14 July after which there were several additional, closely spaced rains (Fig. 1). The vegetation responded minimally to the first rain but much of the new growth dried considerably between rains. The second and subsequent rains initiated and maintained the usual spectacular summer growth of vegetation. There was no emergence or immigration of butterflies with the first rain. The second rain, however, was followed by a rapid increase in species number and abundance similar to the increase after the first rain of 1970. The timing of the autumn decrease was similar to 1970.

The 3 principal spring species showed a peak in about late May or early June with continued emergence into early fall as noted above. Several patterns were evident among the rainy season species. Certain resident species showed an immediate emergence within a few days of the first rain. These included *A. leilia*, *D. chara*, *P. catullus* and possibly *E. funeralis*. Other species including the immigrant *D. gilippus*, *P. sennae* and possibly *C. caesonia* and the resident *E. nicippee* occurred in peak numbers 2-4 weeks after the beginning of the rains. The second brood of *A. palmeri* was timed similarly. Additional immigrants, *V. cardui* and *B. philenor*, showed peak abundance about 2 months after the beginning of the rains. In both years, however, *L. bachmanii* reached peak abundance in mid-September. In all other instances where sufficient records exist, the summer peak in abundance was later in 1971 than in 1970 similar to the overall pattern for all species combined as discussed above. Nearly all species had greater peak abundance in 1970 than in 1971.

The relationships of the various species within a larval food plant guild are complex. Adults of the principal *Prosopis* feeders, *A. palmeri* and *H. ceraunus*, were spring fliers with the latter flying slightly later than the former although *A. palmeri* had a relatively large brood after the rains in 1970. Another *Prosopis* feeder, *M. leda*, emerged only after the rains

began. Of the two species which feed as larvae on *Cassia*, *E. nicippee* was resident and *P. sennae* was an immigrant. Both showed peak abundance from early August to mid-September. There was almost complete overlap of peak flight activity in 1970 but *P. sennae* showed peak abundance earlier than *E. nicippee* in 1971. The *Celtis* feeding guild, represented by *A. leilia* and *L. bachmanii*, showed overall peak abundance in mid-September. The two years differed with little overlap in peak flight period in 1970 and almost complete overlap in 1971.

The few notes taken on adult resource use indicate use of several flowering species. The spring species were most often seen visiting *Acacia* and *Prosopis* flowers. In summer, flowers of *Mirabilis multiflora* (used principally by *P. catullus*), *Ipomoea coccinea* (*B. philenor*), *Hymenoclea salsola* (*D. gilippus*, *L. bachmanii*) and *Zinnia pumila* (*D. chara*, *E. claudia*) were visited.

Temporal partitioning may be partly responsible for increased diversity of some butterfly populations (Clench 1967). Replacement of one set of species by another within a season allows increased diversity without increasing competition for adult resources. It must be recognized, however, that the observed phenology of adult activity is often closely integrated with the phenology of immature stages which is largely beyond the scope of the present discussion.

The numerical data in Table 2 were analyzed using the methods of MacArthur (1964) and Ricklefs (1966). Season length was calculated using the information-theoretical measure (H') for the combined abundance of all species (total season) and for each species that was observed in 4 or more 10 day periods (specific season). The specific seasons were averaged and divided into the total season resulting in a figure which indicates species turnover through the total flight season. Use of H' places greater weight on periods of abundance and less on periods of rarity and more accurately reflects the length of the flight period than extreme dates.

Total season length was about 11 ten-day periods in both years (11.4 in 1970, 10.7 in 1971) and average specific season was over 5 ten-day periods (5.31 in 1970, 5.26 in 1971). There appeared, therefore, to be two turnovers among the species present. The turnover in 1970 was obvious with the rainy season species clearly replacing the spring species. The 1971 replacement was less clear but apparently involved the replacement of early rainy season species by those of the later parts of rainy season. While this may have had some effect in 1970, it was largely marked by the large spring broods and longer rainy season of that year.

In general, the phenological patterns were similar to those found by

Brown (1965). The major differences were that Brown did not find spring broods of *A. palmeri*, *L. marina* and *H. ceraunus*, although he found *L. bachmanii* and *D. chara* in spring, two species which I did not observe. In southwestern New Mexico, Ferris (1976) also found phenology to be relatively similar to southern Arizona. He noted a spring brood of all of the above 5 species.

Voltinism

Voltinism varied both inter- and intraspecifically (Table 2). Two (*D. chara*, *P. catullus*) of the 9 common residents were univoltine during both years. *E. nicippe* and *E. funeralis* appeared to be so in 1971 but were at least bivoltine in 1970. Eight rare species were encountered frequently enough to determine voltinism. In 1970, *M. leda*, *P. communis* and *C. hippalus* were univoltine whereas *S. melinus*, *E. amyntula* and *N. iole* were bivoltine. In 1971, *L. eufala* was univoltine and *H. isola* was bivoltine. Thus 33% of the resident fauna was univoltine in 1970 and 46% in 1971. Univoltine species, in all cases, appeared in summer after the beginning of the rains. Univoltinism in other long summer faunas is principally a spring and early summer phenomenon (Shapiro 1975). The mid- to late summer univoltinism in southern Arizona is undoubtedly related to the greatly increased suitability of the habitat following the summer rains.

The remainder of the Santa Rita fauna was at least bivoltine. Three species (*A. palmeri*, *L. marina*, *H. ceraunus*) had large spring and smaller summer broods, especially in 1971. The summer populations were represented by scattered individuals observed over a period of 2–3 months. In 1970, *A. palmeri* may have had 4 broods. These 3 species may be spring univoltines in years when the summer rains fail.

Four rare species (*S. melinus*, *E. amyntula* and *E. funeralis* in 1970 and *H. isola* in 1971) had a distinct brood in early June and at least one other of about the same size following the beginning of the rains. *S. melinus* and *H. isola* appeared to have but one post-rain brood; the others possibly 2 or 3. In both years, small numbers of *A. leilia* occurred before the rains. There were 3 distinct peaks possibly indicating 3 additional broods after the rains in 1970, but in 1971 there was but one large peak in mid and late September. Fresh individuals were noted throughout the flight season of both years indicating continued emergence.

Emergence was limited to after the rains in *L. bachmanii*, *E. nicippe* and *N. iole*. *L. bachmanii* had a small brood immediately after the beginning of the rains, a large brood in September and possibly another one or two smaller broods still later in the season. *E. nicippe* appeared

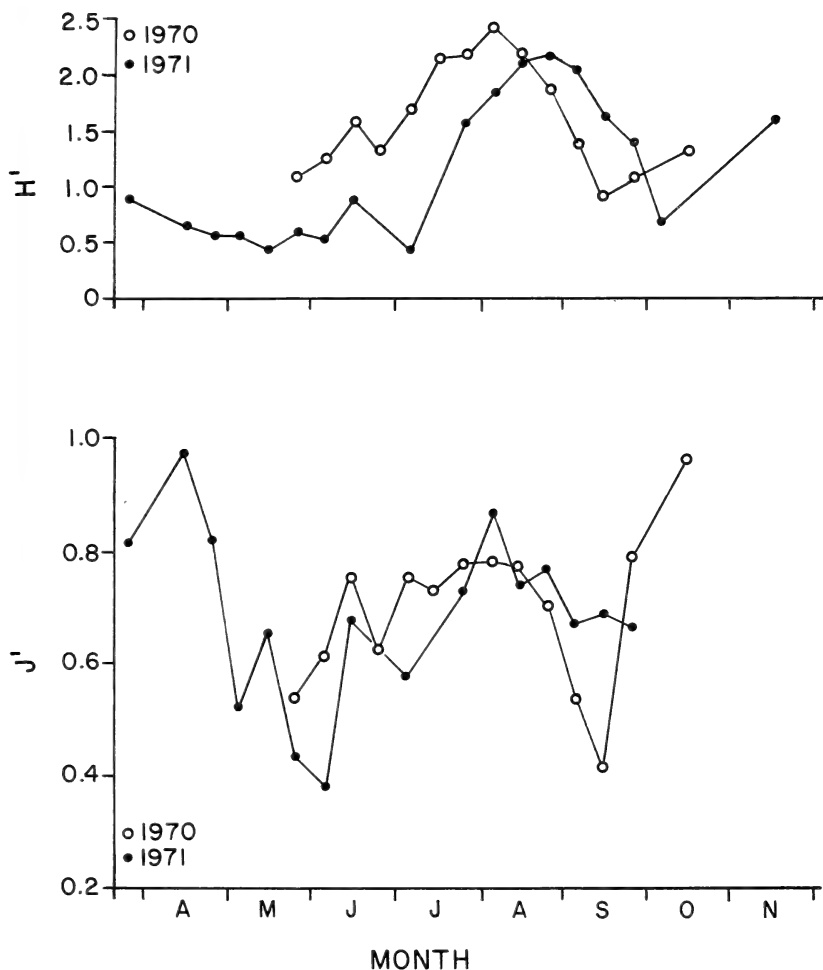


Fig. 2. Seasonal changes in species diversity (H') and equitability (J') of butterflies on the Santa Rita Experimental Range, Arizona.

to have at least 2 broods in 1970 but probably only one in 1971 unless the October records were of an additional brood. *N. iole* had at least 2 broods in 1970 but was all but absent in 1971.

Two immigrant species (*D. gilippus*, *P. philenor*) occurred in small numbers before the rains and reached a definite peak in numbers in late summer. *P. sennae* also showed a peak in abundance after the rains. Other immigrant species occurred irregularly in low numbers after the rains. Unworn individuals of these species occurred throughout the season.

Species Diversity

Diversity of a population can be examined in several ways. The method most often used for butterflies is species counts for each of several seasons. This diversity measure for the Santa Rita fauna was examined previously (Fig. 1). Another measure of diversity based on information theory (H') accounts for both species numbers and relative abundance. This measure has not been widely used for insect populations (Janzen and Schoener 1968) mainly because of the wide range of detectability of the component species (see Shapiro 1975). In this study, I made a concerted effort to obtain accurate counts in a relatively narrow transect and none of the species encountered were particularly secretive. I believe that no species was grossly under- or over-represented in my counts and that the numbers in Table 2 reflect the true relative abundance. Therefore, I used these values to calculate H' for each 10 day period of the two seasons. The ratio of H' to maximum diversity possible if each species were equally abundant is another component of diversity termed equitability (J' , see Pielou, 1966). These were also calculated for each 10 day period.

Diversity, measured by H' , showed a seasonal pattern which closely paralleled species counts (Fig. 2). Linear regression analysis showed that the number of species explained over 80% of the variation in H' ($r = .899$, $N = 31$). In contrast, equitability fluctuated widely, showed no correlation ($r = .005$) with species counts and was most constant during the rainy season (Table 2). Considering each season as a whole, H' and J' were slightly greater (2.34 and 0.67) in 1970 than in 1971 (2.20 and 0.63). The average J' for Santa Rita butterflies of about 0.65 is slightly lower than the average of 0.74 calculated for insect populations containing a larger number of orders and thus greater trophic diversity (see Austin and Tomoff, in press).

CONCLUSIONS

The complexity of the phenology of the southern Arizona butterfly fauna was first indicated by Brown (1965). He noted that most lowland species were rainy season fliers or had a spring brood and additional broods during the rainy season. He further recognized the wide annual fluctuations with populations dependent on the local precipitation.

Several factors seem apparent in the flight patterns of the species present. Strict seasonal phenology with only the magnitude affected by rainfall was exhibited by the 3 principal spring species and by *L. bachmanii* in fall. Spring flight by the *Prosopis* feeders is timed for the larvae to take advantage of the fresh herbage or flower buds and for the adults'

nectar source which appears to be mainly *Prosopis* and *Acacia*. The second brood of *A. palmeri* appears timed to the new herbage growth by *Prosopis* following the summer rains. Flowering by *Prosopis* following the rains is limited and this may account for the very small numbers of *L. marina* and *H. ceraunus* at this season.

The flight seasons of the remaining species are nearly limited to after the beginning of the summer rains. This suggests that rainfall itself and/or the resultant increase in humidity combined with the warm summer temperatures act to break diapause of the resident species. The rapidity of which adults appear after the first rain may relate to the stage of the life cycle at which diapause occurs or to a cumulative effect of successive rains. The enforcement of diapause by heat and aridity in desert regions has been previously noted (Wiltshire, 1956). Non-resident individuals of wide ranging species may be attracted by increased vegetation growth and flowering by many plants. Adults of 12 species of butterflies were observed feeding at the flowers of 2 plant species, *Mirabilis* and *Zinnia*, which flower abundantly and nearly exclusively after the rains begin. The nearly consistent lateness of the 1971 season compared to 1970 (Table 1) is further indication that rainfall is the important ultimate factor in the phenology of many species.

The seasonality of the Santa Rita Range butterfly fauna differs considerably from other temperate zone faunas previously examined. The general trend in most populations is for a rather rapid increase in species number to a mid summer peak and then a decrease into autumn (Shapiro, 1975). Only the tidal marsh in California showed a peak in species numbers in late summer or fall. No temperate butterfly community showed the strict dependence on summer rains. These differences in phenology (and voltinism) can be largely attributed to climatic differences; the areas studied by Shapiro (1975) were largely Mediterranean or Mediterranean-montane in climate. The Arizona community was similar to others, however, in that peak populations corresponded to peak vegetation growth. Seasonal phenology in southern Arizona shows certain similarities to that in the Neotropics where Ebert (1969) found peak activity during the rainy season.

ACKNOWLEDGMENTS

This study was conducted while I was funded to study birds by the US/IBP Desert Biome Program under National Science Foundation Grant GB15886 at the University of Arizona. I thank Donald Thomas and Robert Ricklefs for critical comments on an early draft of the manuscript.

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A NEW HINDWING ABERRATION OF *CATOCALA* *MICRONYMPHA* GUENÉE FROM KENTUCKY

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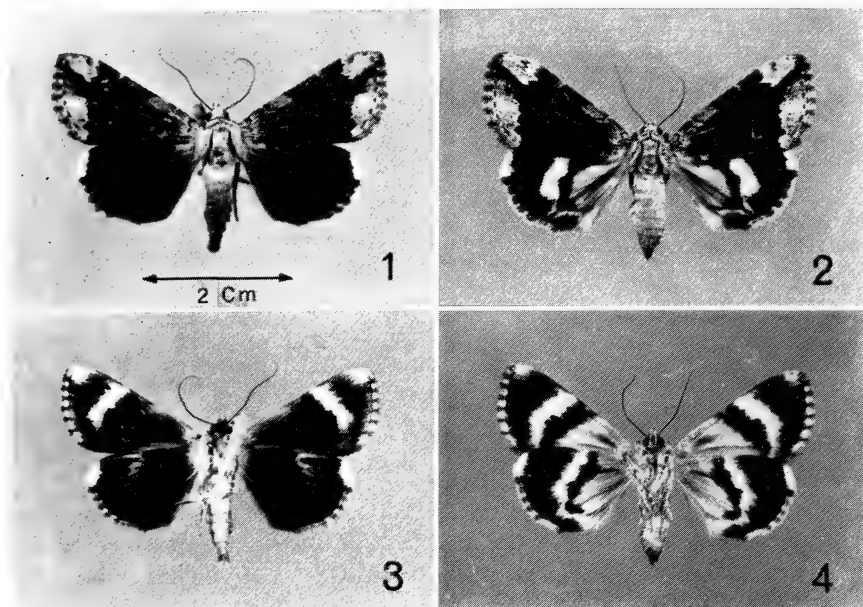
ABSTRACT. An aberration of the underwing *Catocala micronympha* Guenée with forewings like "form gisela" and entirely black hindwings is described from Oldham County, Kentucky. It is informally named "form sargenti" in honor of Dr. T. D. Sargent.

Catocala micronympha Guenée was very common in Kentucky in June and July 1977, and a large number of specimens representing the various forewing variations was collected in several counties. On the night of 15 June I took at blacklight a single male of what appears to be the first known individual with forewings of form "gisela" Meyer, but with hindwings completely black on the upperside except for the yellowish-white terminal line, fringe, and apical patch (Fig. 1). The underside of the hindwing has a diffuse remnant of the median yellow band below the costal margin (Fig. 3). Wingspan is 4.4 cm. A typical form "gisela" from Bernheim Forest, Kentucky, also taken on 15 June 1977, is shown for contrast (Figs. 2, 4).

The locality from which this specimen was taken was the University of Louisville's research farm, the Horner Bird and Wildlife Sanctuary, about 20 miles (32 km) southeast of Louisville in Oldham County, near the hamlet of Brownsboro. No *Catocala* aberrations of any kind had been collected or seen there in over 12 years of fairly heavy collecting until this collection was made. No achromatic hindwing aberrations of *C. micronympha* were reported in Barnes and McDunnough (1918), Forbes (1954), or Sargent (1976). Personal communication with Drs. T. D. Sargent and D. C. Ferguson leads me to conclude that this specimen is unique.

Sargent (1976) states that, "... hindwing polymorphisms are virtually unknown . . ." in *Catocala* (p. 77), while the forewings in some species (such as *micronympha*) are highly polymorphic. Single examples of hindwing aberrations are also rare. He further states (p. 111) that, "In the *Catocala* the most prominent "sports" are those involving substantial alterations of the normally invariable hindwings of a species." Those eastern North American underwings for which there are named aberrations involving all-black or nearly all-black hindwings, where contrasting light-colored bands are typical, include the following (with descriptions from

¹ Univ. of Louisville Contributions in Biology No. 190 (New Series).



Figs. 1-4. *Catocala micronympha* Guenée. 1. aberration "sargenti" Covell, upper-side; 2. form "gisela" Meyer, upperside; 3. aberration "sargenti," underside; 4. form "gisela," underside.

Sargent): *C. muliercula* Guenée, ab. "peramens" Hulst ("HW almost entirely black"); *C. ilia* (Cramer), ab. "normani" Bartsch ("blackish FW from base to pm line, and extended black on HW"); *C. unijuga* Walker, ab. "fletcheri" Beutenmuller ("HW entirely black"); *C. grynea* (Cramer), ab. "constans" Hulst ("HW almost totally black"); and *C. habilis* Grote, ab. "depressans" Sargent, named by him on the basis of a single specimen with nearly all-black hindwings which escaped his killing jar (Sargent, 1976, p. 111, 113; Plate V, 2).

While Latinized names for aberrations have no standing in zoological nomenclature, Dr. Sargent coined "depressans" and 3 melanic form names in his book as convenient "handles" for such forms. I am therefore following his example and name the new aberrant form *Catocala micronympha*, aberration "sargenti," in honor of Dr. Theodore D. Sargent in recognition of his contributions to the study of North American *Catocala*.

The specimen on which this name is based is now in my possession, but will be deposited in the U.S. National Museum of Natural History at a later date.

Note added in proof: On 6 July 1978, Loran D. Gibson collected a second male of this new form at light at Otter Creek Park, Meade County, Kentucky. The specimen was in worn condition, and is in the collection of the University of Louisville.

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CONFIRMATION OF THE OCCURRENCE OF AN ALBINISTIC FEMALE
FORM OF *PHOEBIS PHILEA* (PIERIDAE) IN EXTREME
SOUTHERN TEXAS

Phoebis philea (Johansson) is a large pierid butterfly common in tropical America. Individuals from Mexico enter southern Texas often (annually according to Howe, 1975, *The Butterflies of North America*, Doubleday, Garden City, N.Y., 633 p.). Males of this species are easily recognized by the striking contrast of yellow and orange portions of the dorsal forewings and hindwings. Females have the marginal dark markings typical of females of the genus, with the yellow and orange wing portions somewhat less contrasting. An albinistic form of *philea* was named "obsoleta" by Niepelt (1920, *Int. Entomol. Zeit.* 14: 17); this form corresponds to albinistic female forms in other species of *Phoebis*.

On 12 August 1961 I collected one "obsoleta" in Brownsville, Cameron County, Texas. The dorsal wing surfaces were quite faded with scales totally lacking in isolated areas, particularly on the forewing discal cell area. Scales still present tend to be lightly greenish white. The ventral wing surfaces were also faded, but orange scales remain in sufficient numbers to provide the general color.

One previous report of "obsoleta" from the extreme southern tip of Texas is known. Stallings and Turner (1946, *Entomol. News* 57: 44) reported a specimen collected in the Lower Rio Grande Valley. H. A. Freeman, who collected this first specimen, has kindly provided the data as follows: 23 August 1944 at a roadside park between Pharr and Hidalgo, Hidalgo County. My second specimen is of interest because local lepidopterists probably are unfamiliar with this form.

Occurrence of *philea* in southern Texas is seasonal, with most specimens being reported from September to November (McGuire & Richard, 1974, *An Annotated Checklist of the Butterflies of Bentsen—Rio Grande Valley State Park and Vicinity*, Texas Parks & Wildlife Department, Mission, Texas, 21 p.). The worn condition of my specimen indicates that it arrived here after long-distance migration from somewhere in northern Mexico. Substantial numbers of *philea* were found at least as far north as central Texas in late summer 1971 following an unusual climatic regime (Neck, unpub. data); no "obsoleta" were seen at this time by local collectors.

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A NEW WEEDY HOST FOR THE BUCKEYE, *PRECIS COENIA* (NYMPHALIDAE)

The Buckeye, *Precis coenia* Hbn., is an opportunistic, oligophagous species hitherto recorded from several genera of the plant families Verbenaceae, Plantaginaceae, and Scrophulariaceae in North America. In the Sacramento Valley of lowland central California it feeds on two species of *Lippia* (Verbenaceae) and one of *Plantago* (Plantaginaceae) (Shapiro 1974, J. Res. Lepid. 13: 120) while in the nearby Vaca Hills it occurs on *Diplacus* (Scrophulariaceae) and at mid-elevations on the Sierran west slope on *Penstemon azureus* Benth. (Scrophulariaceae). In the San Francisco Bay area it has been found on garden snapdragons (*Antirrhinum*), an introduced scroph. On 17 September 1977 an infestation of fifth-instar larvae, probably from a single colonization event, was found on large mats of fluellin, *Kickxia spuria* (L.) Dumort, growing in cracks in an abandoned roadway at Davis, Yolo Co., California. This Mediterranean scroph is closely related to toadflax (*Linaria*) and to snapdragon and occurs sporadically in lowland California as a pavement and roadside weed. In captivity the larvae ate leaves, buds, flowers and fruit freely. No recorded hosts of any plant family could be found within 30 m of the infested plants. Adult *P. coenia* were present.

Fluellin is a prostrate perennial plant with cordate, dull green, pubescent leaves less than 1 cm long. The flowers, which are open mostly in the morning, are snapdragon-like, with a long spur; they are purple and bright yellow and about 1 cm long. The stems, which may be 50 cm long, form tangled mats up to a meter across.

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A SECOND LOCALITY FOR *EULYTHIS MELLINATA* (GEOMETRIDAE) IN NORTH AMERICA

While identifying some Nova Scotian moths for James Edsall of Halifax, a specimen of *Eulythis* was examined which resembled no species known to occur in the province. A check on the identity of the specimen at the Nova Scotia Museum showed it represents a Palearctic species, *Eulythis mellinata* F. (South, 1972, *The Moths of the British Isles*, Warne, London, 379 p.), a new provincial record and the second locality in North America where this moth has been collected. Sheppard (1975, *Ann. Entomol. Soc. Québec* 20: 7) recorded this species from Laval, Québec, under the name *associata* Borkh.

Eulythis mellinata is a widespread Palearctic species. In Europe and Britain the larvae feed on red and black currant (*Ribes rubrum* L. & *R. nigrum* L.). Mr. Sheppard informs me that this species has probably become established on Mountain (Alpine) currant (*Ribes alpinum* L.) hedges in the vicinity of his home at Laval, Québec.

The Nova Scotian specimen is a fresh female and was collected on 31 July 1972 at light in Arundale, Halifax, Nova Scotia. Other captures have been recorded in North



Fig. 1. *Eulythis mellinata* F. Female from Armdale, Halifax, Nova Scotia. 31 July 1972. J. Edsall. 3.5 \times .

America at Laval (Isle Jesus), Québec on 10 July 1967 (1 male), 24 June 1973 (1 female), 1 July 1973 (1 male) (Sheppard 1975, Ann. Entomol. Soc. Québec 20: 7), 28 June 1974 (1 male), 7 July 1974 (1 female), 29 June 1975 (1 female), 18 June 1976 (1 male) and 24 June 1976 (1 male) (Sheppard, 1977, pers. comm.).

The introduction of *Eulythis mellinata* in Nova Scotia was almost certainly recent as the specimen was collected in an area which has been intensively collected for the last 30 years, yet this is the only specimen which has been taken to date. The occurrence of the moth in two widely separated localities in eastern Canada indicates well-established populations, and its occurrence in other eastern North American localities should therefore be expected. A photograph of the adult has been included to aid in identification.

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OCCURRENCE OF *THYMELICUS LINEOLA* (HESPERIIDAE) IN NEWFOUNDLAND

The recent rapid spread of the European Skipper, *Thymelicus lineola* (Ochsenheimer) in North America, particularly in the northeastern part of the continent, evi-

dently has excited considerable interest (Burns 1966, Can. Entomol. 98: 859-866; Straley 1969, J. Lepid. Soc. 23: 76; Patterson 1971, J. Lepid. Soc. 25: 222). As far as Canada is concerned it is now listed (Gregory 1975, Lyman Entomol. Mus., McGill Univ., Ste-Anne de Bellevue, Québec, p. 11) as occurring in the provinces of Québec, New Brunswick, Nova Scotia, and British Columbia, as well as Ontario, where it was first noted on this continent in 1910 (Saunders 1916, Ottawa Nat. 30: 116).

The butterfly was certainly present in great numbers in one spot in northeastern Nova Scotia (Cape Breton Island) on 26 July 1977 where I found it on grassy wasteland adjacent to an abandoned coal mine at Sydney Mines. This is 3 km north of Sydney whence the ferry sails for Newfoundland, a voyage of 160 km across the Cabot Strait. Having arrived in Newfoundland, I found *T. lineola* in the western part of the island, on 28 July 1977. The locality was an open grassy area a few metres wide between woodland and Highway 430, 15 km north of Deer Lake. About a dozen of the butterflies (all males) were observed, most being fresh specimens. Three specimens were collected and have been deposited in the Can. Nat. Coll., Ottawa.

Holland (1969, J. Lepid. Soc. 23: 33-42) collected in the Deer Lake area in 1965 at the same time of year and did not report seeing this species; indeed it does not appear to have been previously reported from Newfoundland. However, the insect has certainly reached the island now, presumably by traversing the Cabot Strait from Nova Scotia in the very recent past. It is perhaps possible that this species used the ferry for the crossing.

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A PROBABLE NATURAL HYBRID OF *PAPILIO EURYMEDON* AND *P. RUTULUS* (PAPILIONIDAE) FROM IDAHO

Natural interspecific hybrids seem to be as rare among swallowtails as they are among butterflies in general. In the field the best evidence for hybridization comes usually from intermediacy of such characters as wing shape and color patterns.

On 18 May 1976, David H. Wagner and I encountered impressive swarms of *Papilio eurymedon* Lucas and *P. rutulus* Lucas visiting muddy spots at the edge of the town of Lowell, Idaho Co., Idaho. All of the individuals were males. Flying at the same place but much less common were *P. multicaudatus* Kirby, *P. zelicaon* Lucas, *Pieris napi* Linné, *Anthocharis sara* Boisduval, *Euphydryas chalcedona* Doubleday and Hewitson, and *Celastrina pseudargiolus* (Boisduval and LeConte). Some of the male swallowtail "clumps" on the moist soil included over 50 butterflies. They were probably seeking sodium (cf. Arns et al. 1974, Science 185: 372-374). Obviously the situation here was ideal for observing variations, and we examined the crowded butterflies carefully in the hope of finding aberrant forms. The differences between *P. eurymedon* and *P. rutulus* were immediately visible as they flew up and settled, often spreading their wings as they crawled over the moist earth. The gray-white ground color of the former contrasted with the bright clear yellow of the latter. Also the much broader black stripes and reduction of ground color of *P. eurymedon* quickly separated it from *P. rutulus*.

In one group of swallowtails we noticed a perplexing individual that did not fit either *P. eurymedon* or *P. rutulus*. Its ground color was whitish lemon-yellow and the

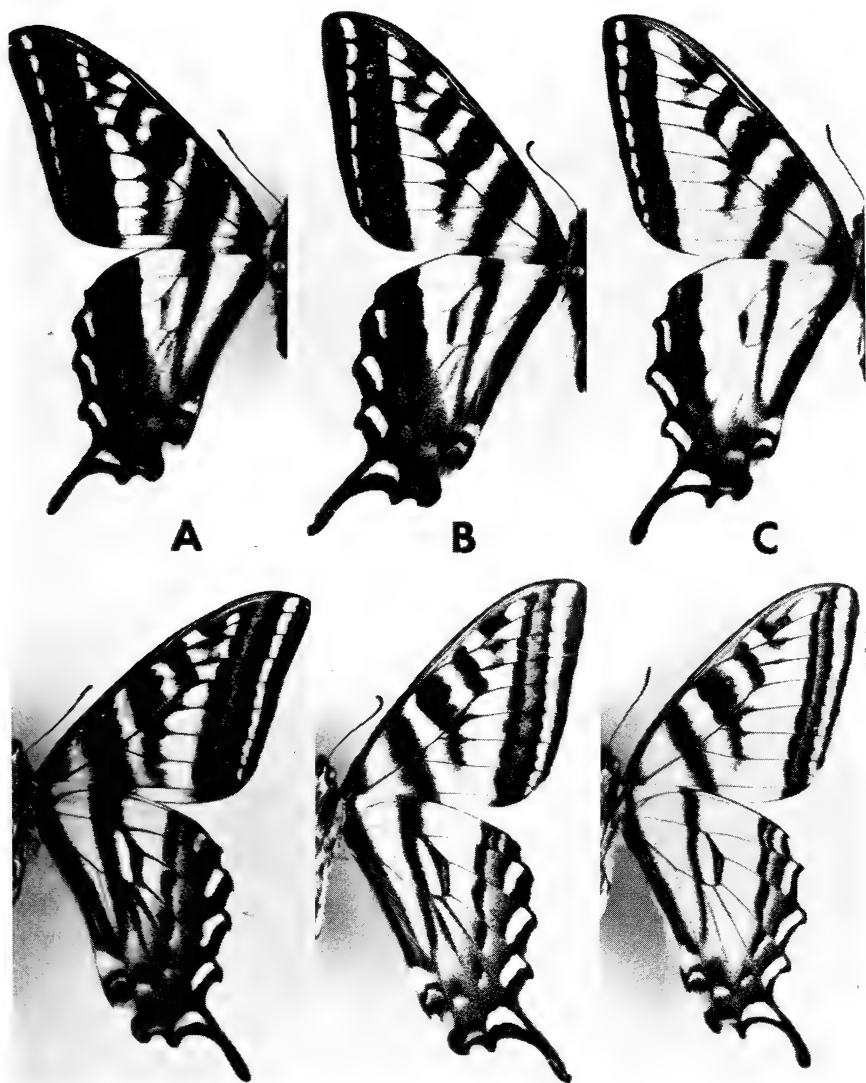


Fig. 1. Male swallowtails from Lowell, Idaho. Above, dorsal view; below, ventral view (magnifications vary slightly). A. *Papilio eurymedon*. B. Probable *P. eurymedon* \times *rutulus*. C. *P. rutulus*.

stripes were of intermediate width. The odd specimen was captured and is illustrated together with examples of the two associated species (Fig. 1). The specimen is intermediate in the position, extent, and shape of practically every stripe and spot. This evidence supports the conclusion that the odd specimen is a natural hybrid between *P. eurymedon* and *P. rutulus*.

We were especially impressed by the precise intermediacy of the individual. Generally speaking hybrid butterflies show such intermediacy, but in some cases they may resemble one parent more than the other. In the genus *Limenitis*, F₁ hybrids of *L. archippus* Cramer and *L. astyanax* (Fabricius) are intermediate, but backcrosses yield both hybrid-like and parent-like morphs (Platt 1975, Evolution 29: 120-141). In swallowtails at least, even F₁ hybrids may sometimes show one-sided intermediacy. For example, Clarke and Sheppard (1957, Lepid. News 11: 201-205) bred female *P. glaucus* L., the eastern North American counterpart of *P. rutulus*, with male *P. eurymedon*, and found that the *glaucus* wing pattern seemed generally dominant to that of *P. eurymedon* (cf. their Fig. 2 with Fig. 1 of the present paper). The F₁ progeny of laboratory crosses of *P. polyxenes* and *P. xuthus* were like the former parent in 11 out of 14 characters (Remington 1959, J. Lepid. Soc. 13: 151-164). Thus it is possible that all individuals of *P. eurymedon* × *P. rutulus* found in nature in the future will not be so conspicuously and precisely intermediate as the one figured here.

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NOTES ON SOME MOSAIC *PIERIS* (PIERIDAE)

Mosaic specimens occur in many if not all species of butterflies and moths, and are of scientific interest in that they can provide clues to the sequence of events occurring in embryonic or post-embryonic development. The origins of several types of mosaics are discussed by Ford (1945, Butterflies, Collins, London, Ch. 9). The mosaic nature may be sexual (various kinds of gynandromorphs) or homeotic (involving the production of a normal feature or pattern in an inappropriate location) or neither.

The checkered white, *Pieris protodice* Bdv. & LeC., is one of the most abundant and widespread North American butterflies and shows a conspicuous sexual dimorphism. There are apparently no published reports of gynandromorphs or other sexual mosaics although a bilateral non-sexual aberration inherited in a Mendelian manner has been reported (Shapiro 1970, Wasmann J. Biol. 28: 245-257). I have never seen a mosaic in any institutional or private collection. Figure 1 shows the first such specimen I have turned up in thirteen years of research on this species, including mass laboratory culture through over 30 generations and repeated field sampling in several states. It was collected in a sample of 10 taken 16 October 1977 at Rancho Cordova, Sacramento Co., California. It is a very unusual gynandromorph for a number of reasons. The entire body and three wings are apparently male. The right forewing appears about 40% female, with the inner margin, discal cell and apex mostly female. There are three black spots near the margin in the interspaces where no black normally occurs in either sex. The female characters are confined to the upper surface. Ventrally the forewings are symmetrical and both male. Thus the assumed chromosomal accident must have occurred in a cell all of whose progeny were fated to positions on the surface giving rise to the dorsal lamina and its scales.

I have on hand a similar mosaic gynandromorph of *Colias eurytheme* Bdv. (figured by Shapiro 1973, J. Res. Lepid. 12: 94) in which the apex of the left forewing is female above, and the rest of the animal male. In this case the sexes do not differ ventrally in the forewing apical area, and it cannot be said with certainty whether

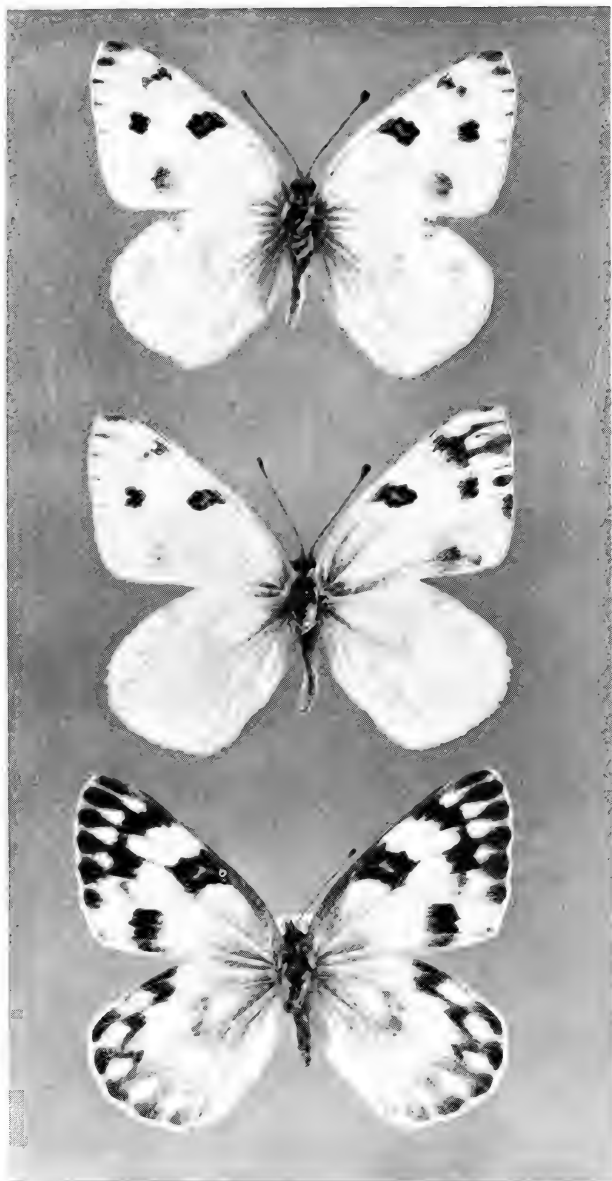


Fig. 1. Normal male (top) and female (bottom) *Pieris protodice* and mosaic gynandromorph (center). All from Rancho Cordova, California, 16 October 1977.

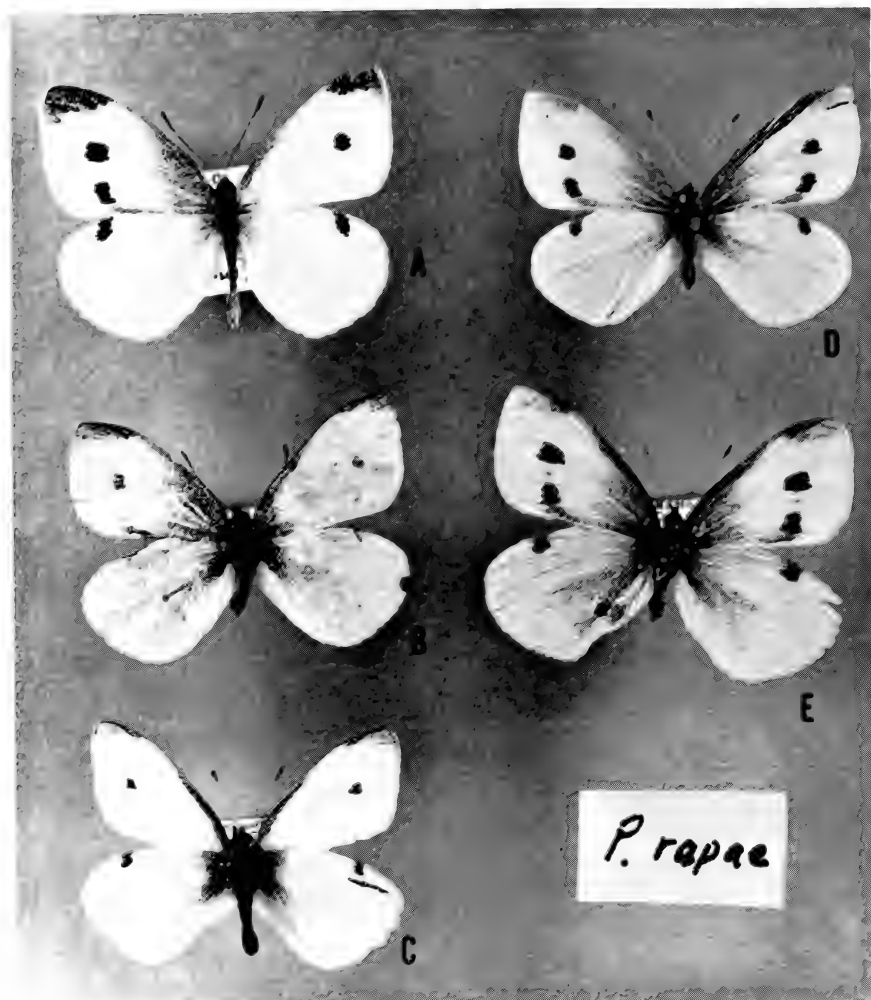


Fig. 2. Mosaic *Pieris rapae* from California. A: bred, Davis, Yolo Co., April 1972; B: wild, Davis, March 1972; C: Southport, Yolo Co., March 1973; D: Sacramento Co., April 1973; E: Suisun Marsh, Solano Co., March 1974.

the specimen is aberrant on both surfaces. The same applies to the *Colias philodice* Latr. figured by Emmel (1964, J. Res. Lepid. 3: 63) as a mosaic gynandromorph. In this case, however, it is unlikely that the specimen is gynandrous at all. The "female" pattern is chaotic and more likely represents patches of male ground color within the black border, a not uncommon occurrence.

Figure 2 illustrates some mosaics of *Pieris rapae* L. from northern and central California. Two of these are clearly sexual. Specimen A is a bilateral gynandromorph bred *ex ovo* at Davis. Specimen B is a rather worn, field-collected specimen. These are the only California gynandromorphs I have seen in this species, and it is of more

than passing interest that B was collected in the same field in the same week as the mother of A. Both specimens show some streaky mosaicism, with patches of male scales on the female side and conversely.

Specimens C through E have abnormal, asymmetrical black markings which are confined to the upper surface. (Mosaics of this sort are very rare on the ventral surface. I have only one *rapae*, a female, with an abnormal black marking confined to the ventral surface and this is a "ray" similar to and perhaps homologous with the Mendelian character found in the *protodice* group (Shapiro 1973, Wasmann J. Biol. 31: 301-311).) In specimen E the shape of the spot suggests homeosis, but it is located in an inappropriate interspace; moreover its position corresponds to an obvious crimp in the dorsal lamina, of the sort to be expected from a deformation of the pupal wing-case. Such injuries may occur when an unhardened pupa slips in its silken girdle. In *Colias* they routinely result in melanization of the area around the injury; if the adult is able to eclose, the resulting pattern is grossly abnormal (compare female figured by Shapiro 1970, Entomol. News 81:50/data document p. 5).

Braun (1939, Biol. Bull. 76: 226-240) showed that as pigment precursor spread outward across the wing from the body, deposition took place in those scales which were sufficiently chitinized at that time. Control of pattern thus depends on the rate of scale maturation, which may be accelerated around injuries—contributing to mosaics such as these. Since injuries are most likely on the dorsal surfaces, especially of the forewings, it is not surprising that mosaicism is commonest there. The black streaking near the costa of specimen D could have arisen in several ways, but that near the hindwing apex of C suggests an injury resulting in pigment deposition in the corresponding scales as a wave of melanin precursor moved across the wing.

All of the specimens figured are in the collection of the University of California at Davis.

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Journal of the Lepidopterists' Society
32(3), 1978, 231-233

A MALE-LETHAL GENETIC FACTOR IN *PHYCIODES THAROS* (NYMPHALIDAE)

During the course of four years of rearing studies using *Phyciodes tharos* Drury, a total of 17 broods was reared of stock from Upper Tyrone Township, Fayette Co., Pennsylvania. Of these, 15 were derived from wild-collected females and the remaining 2 from wild-laid egg patches found on leaves of the foodplant, *Aster simplex*. Exact egg-hatch data were kept on 16 of the broods, viability and sex ratio data on 13. Of the 17 broods, 3 showed almost total male inviability. In 2 of these 3, most mortality appeared to be during embryonic development, whereas in the third there was normal embryonic viability but about 50% mortality between the first and fourth larval instars. An additional brood (77-63) reared from a wild female collected in Rochester Mills, Indiana Co., Pennsylvania, showed greatly reduced embryonic viability and an almost total absence of male adults (Table 1).

Female progeny from two of the abnormal Fayette Co. broods (74-4, 76-2) were mated to males from normal broods of the same population. Each of these isofemale lines (A and B) showed a tendency toward lowered egg fertility ($P < .001$, Wilcoxon on

TABLE 1. Egg fertility, embryonic viability, adult sex ratio, and prepupal and pupal mortality in broods of *Phyciodes tharos* from wild-collected eggs and females. "Male-lethal" broods indicated by asterisks.

Brood No.	No. of Eggs	Proportion Fertile	Proportion Hatched	Total Adults	Proportion Males	Proportion Mortality
73-1	199	1.000	1.000	75	0.493	0.053
73-2	167	1.000	1.000	140	0.464	0.021
73-3*	557	0.978	0.724	207	0.010	0.019
73-4	638	1.000	1.000			
73-29	229	1.000	1.000	56	0.428	0.036
73-30				21	0.523	0.381
74-1	162	1.000	1.000			
74-2	472	0.998	1.000			
74-3	243	0.992	0.984			
74-4*	45	1.000	1.000	~23	0.000	0.000
75-5				161	0.578	0.012
75-7	220	1.000	1.000	212	0.524	0.042
75-8	258	0.992	0.976	126	0.484	0.008
75-54	289	0.990	0.996	160	0.519	0.025
75-66	135	1.000	0.985	77	0.416	0.130
75-67	25	1.000	1.000	21	0.762	0.000
76-2*	72	1.000	0.444	118	0.000	0.025
77-63*	484	0.983	0.736	174	0.023	0.172

TABLE 2. Egg fertility, embryonic viability, adult sex ratio, and prepupal and pupal mortality in "male-lethal" isofemale lines of *Phyciodes tharos*.

Brood No.	No. of Eggs	Proportion Fertile	Proportion Hatched	Total Adults	Proportion Males	Proportion Mortality
Isofemale Line A						
74-15	131	0.191	0.333			
74-16	417	0.858	0.640			
Isofemale Line B						
76-10	106	0.066	0.714			
76-11	746	1.000	0.614	126	0.000	0.103
76-13	611	0.988	0.778	79	0.076	0.025
76-14	84	0.060	0.800			
76-15	226	0.279	0.714	24	0.083	0.000
76-16	1048	0.995	0.715	150	0.000	0.033

two-sample test) and sharply reduced embryonic viability ($P < .001$) compared with the normal broods. Four broods were reared through to adults in Line B. Each of these showed almost total male inviability ($P = .001$) (Table 2). In none of the "male-lethal" broods was there an unusually high incidence of mortality during the prepupal and pupal stages. The male lethal crisis appears to occur during embryonic or larval development.

Robinson (1971, *Lepidoptera Genetics*, Pergamon, New York, 687 p.) has discussed male-deficient broods in several species of *Lepidoptera*. In *Abraxas grossularia* L. (Geometridae), a karyotypic aberration in females gives a tendency to produce nearly unisex but normally viable broods. In *Hypolimnna misippus* L. (Nymphalidae), females from some small island populations produce all female broods with reduced embryonic viability. Here a dominant sex-linked gene has been postulated.

Owen (1966, *Heredity* 21: 443-451) has investigated East African populations of *Acraea encedon* L. (Acraeidae), some of which contained only 0.6 to 6.2% males. Eggs produced by wild-collected females showed normal viability. Parthenogenesis was ruled out, and the genetic basis of the unisexual broods remains unknown.

The present case in *P. tharos* appears to be similar to that in *H. misippus*. Presumably, in both cases the disadvantage of heavy selection against male progeny is offset by some selective advantage to the females carrying the tendency toward unisexual broods.

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Journal of the Lepidopterists' Society
32(3), 1978, 233-234

OVIPOSITION BEHAVIOR OF COLONIZED *HYALOPHORA GLOVERI GLOVERI* (SATURNIIDAE)

Efficient collection of eggs is an important aspect of maintaining small colonies of giant silkworm moths as breeding stock. This can be accomplished by establishing an oviposition profile for the species being reared and collecting eggs only during the period of peak oviposition. Experience in rearing many species of Nearctic giant silkworm moths has shown that most eggs are deposited during the first few nights after mating. Oviposition profiles reported for *Hyalophora cecropia* (Linnaeus) (Taschenberg & Roelofs 1970, *Ann. Entomol. Soc. Amer.* 63: 107-111) and *Callosamia promethea* (Drury) (Miller & Cooper, 1977, *J. Lepid. Soc.* 31: 282-283) are specific examples of this pattern. This paper reports oviposition data for a small breeding-stock colony of *Hyalophora gloveri gloveri* (Strecker) maintained on wild black cherry (*Prunus serotina*) in Frederick County, Maryland. Because of the small size of the colony (≤ 12 individuals) observations were limited to five individuals.

Five female moths, each of which mated on the first night after emergence, were placed in brown paper bags (lunch size) on the first night after mating; and were transferred to new paper bags each night thereafter until death. After a period of time sufficient to allow all eggs to hatch, the bags were opened to record the number of eggs deposited and the number hatched.

The average longevity of the females after mating was 6.6 days; two individuals lived for 6 days and three lived for 7 days. The females deposited a total of 776 eggs during the study. The maximum number of eggs deposited by a single female was 198; the minimum number was 114. The average number of eggs deposited per female was 155.2. Percent hatch was moderate for eggs deposited during the first 4 nights after mating, the average ranging from 60.7% to 78.4%. The total number of larvae produced per female ranged from 60 to 137; the average being 103.2. The

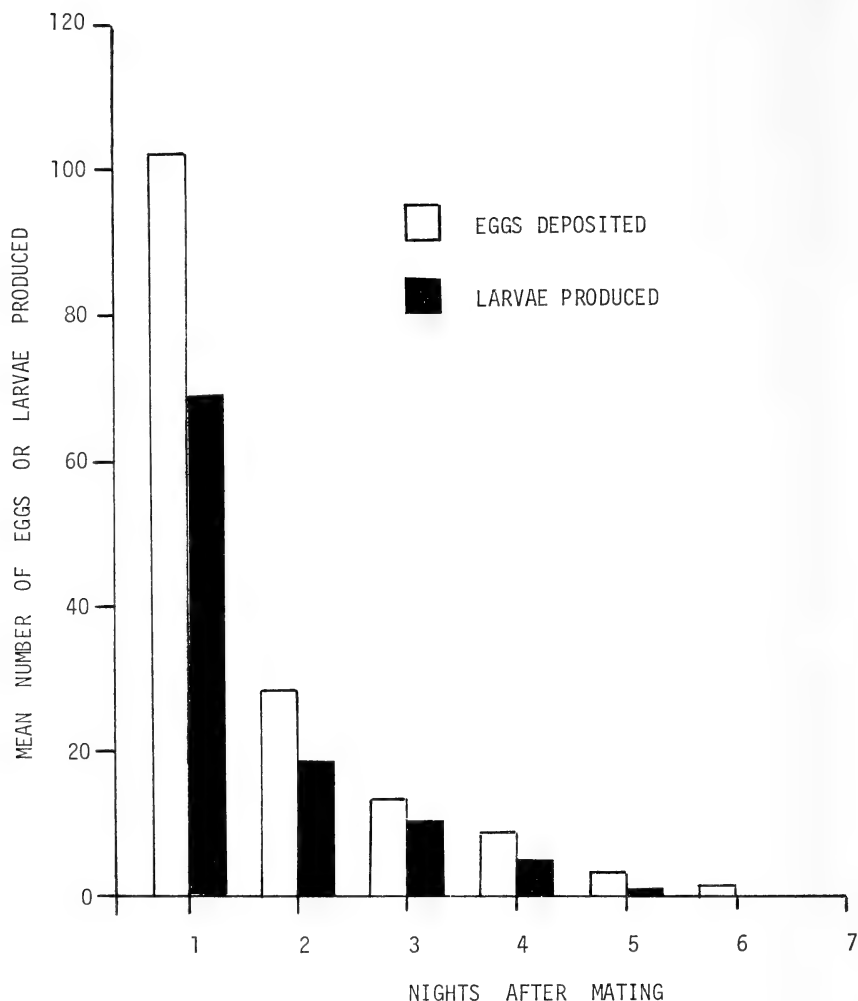


Fig. 1. Oviposition profile for colonized *Hyalophora gloveri gloveri* females.

oviposition profile shown in Fig. 1 indicates that *H. gloveri gloveri* follows the general pattern reported for other species; and that the optimum time for collecting eggs to maintain small colonies for breeding stock is during the first night after mating.

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(This research was not supported by government funds; the opinions contained herein are those of the author and should not be construed as official or reflecting the views of the Department of the Army.)

Journal of the Lepidopterists' Society
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THE MURRAY O. GLENN COLLECTION OF MICROLEPIDOPTERA

The collection of microlepidoptera assembled from 1931–1976 by Murray O. Glenn has contributed significantly to the classification and ecology of the Lepidoptera of the midwestern prairies in the USA. It includes ca. 30,000 carefully prepared moths representing 1325 identified species, 949 of which Glenn collected in the prairies, wooded bluffs, and bottomlands near the Illinois River and its tributaries in Putnam and Marshall counties in north-central Illinois.¹ Significantly the area is now the type-locality for 17 species and at least one additional species that currently is being described.

The species that have been named from the Glenn collection with Putnam County as the designated type-locality include the following:

OLETHREUTIDAE. *Polychrosis sambuci* Clarke, *Endothenia microptera* Clarke, *Exartema comandranum* Clarke, *Eucosma uta* Clarke, *Epiblema naomi* Clarke, and *Epinotia atristriga* Clarke.

COSMOPTERIGIDAE. *Teladoma incana* Hodges.

MOMPHIDAE. *Batrachedra illusor* Hodges and *Chedra inquisitor* Hodges.

WALSHIIDAE. *Periploca cata* Hodges, *Aeaea venifica* Hodges, *Sorhagenia baucidis* Hodges, and *Perimede maniola* Hodges.

GELECHIIDAE. *Chionodes asema* Clarke and *Dichomeris glenni* Clarke.

OECOPHORIDAE. *Agonopterix dimorphaella* Clarke.

PTEROPHORIDAE. *Oidaematophorus glenni* Cashatt.

The holotypes for all the above named species are at the U.S. National Museum of Natural History (USNM) except for *Oidaematophorus glenni* which is in the collection of the Illinois Natural History Survey (INHS).

Glenn, in 1977, donated his private collection to the INHS and the USNM, the former institution receiving the identified specimens (ca. 20,000) including numerous paratypes and the latter all unidentified moths (ca. 10,000). (His collection of macrolepidoptera was given to the INHS in 1969.)

Glenn, as a collector, “. . . seemed to have a genius for coming up with rare and desirable things.” (Klots, pers. comm.). In addition to collecting, he succeeded in ascertaining natural foodplant associations for many of the species that he encountered. Much of this information is presently available only by examining the collection itself but should prove extremely useful to future studies if coupled with the 46-year compilation of flight records associated with the specimens and environmental changes induced by natural or artificial factors.

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¹ All specimens collected by Glenn in this defined region are labelled “Putnam Co., IL.” However, it should be noted that while Glenn did most of his collecting in Putnam County he occasionally forayed into the adjoining portions of Marshall County.

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A NEW RECORD FOR *CALYCOPIS CECROPS* (LYCAENIDAE) IN COLORADO BY AIRCRAFT-INTRODUCTION

A new butterfly record for Colorado, *Calycopis cecrops* (Fabricius), was collected by Howard Bone, in the rear cargo pit of a United Airlines 727 at Stapleton International Airport, Denver, on 12 July 1977. The flight was a charter from the east coast arriving in Denver around 1030 MDST. The cargo pit doors of such aircraft are left in the open position the entire time the aircraft is on the ground, and this can easily be from 30 minutes to over an hour, which is ample time for any insect to fly into the pit. The mentioning by others (Eliot 1977, J. Lepid. Soc. 31: 75; Riotte 1977, J. Lepid. Soc. 31: 182) that Lepidoptera can be transported by both military and commercial airliners is confirmed by this record.

Another possibility of an aircraft-introduced species is that of *Tmolus azia* (Hewitson). This species has been collected in the state twice. The first specimen was collected by Jim Eff on 16 July 1957, Chatauqua Mesa, Boulder Co., Colorado. The second specimen was collected by Marc Epstein on 26 July 1975, Magnolia Rd., Boulder Co., Colorado. These records are both equidistant from the airport. The facts that 1) there are no other records from the state, that 2) they were collected about the same time of year, and that 3) there were no other records during the 18 year interval, suggests the possibility these two specimens were introduced by aircraft.

This unusual occurrence of stowaways on aircraft could provide a very logical explanation for the introduction of butterflies at great distances from their normal ranges. A butterfly could easily fly into the pressurized, air-conditioned cargo pit of an aircraft, and be flown across the country or overseas in a matter of a few hours.

The normal range of *Calycopis cecrops* is from eastern Kansas through southern Ohio to southern New Jersey and southward to Florida and Texas. The closest distance to Colorado within this range is approximately 500 air miles (805 km), but this specimen traveled some 1500 air miles (2414 km) from the east coast inside an airplane. The normal range of *Tmolus azia* in North America is southern Arizona and southern Texas, which is approximately 600 air miles (966 km) from Colorado.

The specimens of *Calycopis cecrops* and *Tmolus azia* (collected by Marc Epstein) are deposited in the collection of the Denver Museum of Natural History.

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Journal of the Lepidopterists' Society
32(3), 1978, 236-238

NEW FOODPLANT AND OVIPOSITION RECORDS FOR THE EASTERN BLACK SWALLOWTAIL, *PAPILIO POLYXENES* ON AN INTRODUCED AND A NATIVE UMBELLIFER

Papilio polyxenes (Fabr.) is one of the most common Papilionidae in open fields of the eastern United States. Its larvae are considered to prefer plants of the Umbelliferae, although in laboratory no-choice situations they will eat several species of Rutaceae. Some individuals can also survive when fed on the cucumber (or mountain magnolia) tree, *Magnolia acuminata* L. (Scriber and Feeny, in prep.).

In Greene County, Ohio, and Ithaca, New York, the preferred foodplant for *Papilio polyxenes* (Fabr.) appears to be the introduced wild carrot, *Daucus carota* (L.), as it likely is for most of the northeastern United States. In the eastern United States, a variety of species of *Umbelliferae* have been reported as foodplants (Scudder, 1889, The butterflies of eastern United States and Canada, 2: Forbes, 1960, Cornell University Agr. Expt. Sta. Memoir #371; Teitz, 1972, An index to the described life histories of Macrolepidoptera of the continental United States and Canada, Vol. 1; Tyler, 1975, the Swallowtail Butterflies of North America, Naturegraph). In addition to carrot, those plants upon which *polyxenes* larvae have been observed naturally in New York (J.M.S.) are wild parsnip, *Pastinaca sativa* L., poison hemlock *Conium maculatum* L., angelica *Angelica atropurpurea* L., and goutweed, *Aegopodium podagraria* L. In 1976, *polyxenes* larvae in Ohio were found (M.D.F.) upon bulb-bearing water hemlock, *Cicuta bulbifera* L., angelica, *Angelica atropurpurea*, and wild parsnip, *Pastinaca sativa* in addition to wild and cultivated carrot. Here we have two separate observations of *polyxenes* on plants which should be reported due to the apparent lack of any previous natural observations and also due to their particular ecological significance.

Our first observation is that of a female ovipositing on a characteristically woodland native plant species, *Cryptotaenia canadensis* (L.), Honewort (Fernald, 1950, Gray's Manual of Botany, 8th ed.). The observation (J.M.S.) was made on 15 July 1977 at 10:00 hrs along a wooded creek at the end of Carlsbrook Drive in the township of Beavercreek, Ohio (Greene County). Conditions were favorable for oviposition, with the temperature approximately 30°C and the humidity also very high. Although these seem to be the ideal conditions for oviposition of most eastern swallowtails, solar radiation was probably a very important contributing factor as well, especially with the potential thermoregulation of body temperature in adults (R. C. Lederhouse, pers. comm.).

Although *P. polyxenes* larvae eat *Cryptotaenia* in laboratory no-choice conditions (Erickson, 1975, Psyche 81: 109-130; Scriber, 1975, Comparative nutritional ecology of herbivorous insects; Generalized and specialized feeding strategies in the Papilionidae and Saturniidae Ph.D. Thesis Cornell University, Ithaca, N.Y.), the adults are rarely seen flying in forested areas where the foodplant occurs. Reasons for use of this particular wooded patch in Ohio are uncertain. This female may have drifted into the area more by chance than choice since the wooded habitat was a rather narrow strip in an otherwise open area of residential lawns and first year successional habitats. Inside the woods the *polyxenes* female hovered and circled several *Cryptotaenia* plants before depositing one egg in an immature flower head. The female did not investigate the other *Umbelliferae* (*Sanicula*, *Heracleum*, *Osmorhiza*) nearby, and instead flew off across the lawns out of sight. Although larvae ate and survived upon *Heracleum maximum* (Bartr.) plants from this same wooded location, post-flowering *Heracleum* plants in mid-July were less suitable for larval growth than were the mid-May plants (Finke, 1977, Factors controlling the seasonal foodplant utilization by the specialized herbivore, *Papilio polyxenes*. (Lepidoptera: Papilionidae) M.S. thesis, Wright State Univ., Dayton, Ohio). We do not know whether the pre-flowering *Heracleum* plants would have been more attractive for oviposition by *polyxenes* in May. *P. polyxenes* larvae from Greene County, Ohio refused to eat *Sanicula gregaria* Bickn., and others died after several days of eating *Osmorhiza longistylis* (Torr.) and *O. claytoni* (Michx.) (Finke, *ibid.*).

Utilization of other woodland umbellifer species, *Taenidia integerrima* and *Thaspium barbinode* by *Papilio joanae* Heitzman may have contributed to reproductive isolation by habitat and the relatively new species status of this *polyxenes* relative (Heitzman, 1973, J. Res. Lepid. 12: 1-10). The significance of habitat as an isolating mechanism for adults and larvae of the two species is an interesting aspect of their ecology which needs further investigation.

Our second observation was made in Ithaca, New York (Tompkins County) on

5 June 1977. Eight *Papilio polyxenes* larvae were observed feeding upon one plant of the introduced Lovage, *Levisticum officinale* (Doch). It is uncertain if these larvae (all of which were molting from the 3rd to 4th instar) were derived from one or several adults. It is extremely unlikely that they wandered onto the *Levisticum* from another plant, as there were no other umbellifers nearby. Larvae were collected and reared through to pupation on *Levisticum*. Adults have been preserved as voucher specimens (at the Univ. of Wisconsin, Madison).

The 1973 and 1974 Ithaca populations of *P. polyxenes* produced larvae which consumed *Levisticum officinale* and grew at rates comparable to those for larvae on 35 other *Umbelliferae* in laboratory no-choice situations (Scriber, *ibid.*). *Papilio polyxenes* larvae obtained from an adult caught in Costa Rica by Paul Feeny all refused to eat or else ate and died in a similar no-choice situation (Scriber, *pers. obs.*). Some *polyxenes* larvae from a Costa Rican female \times Ithaca male mating were, however, able to eat *Levisticum* and grew to the 2nd and 3rd instar before the culture was lost to virus (J.M.S. and R. C. Lederhouse). The genetic basis for this feeding ability remains undetermined. Some recent studies with Costa Rican *polyxenes* larvae indicate a marginal and variable ability to utilize *Levisticum* does exist in this Central American population (Wm. Blau, *pers. comm.*).

The *Levisticum officinale*—*Papilio polyxenes* interface would appear to offer a good system for investigation of the evolutionary dichotomy underlying differences in ovipositional and larval feeding stimulants. The closely related *P. machaon* in Sweden, for instance, will oviposit freely on *Levisticum*, but 100% of the larvae die feeding on it (Wilkund, 1975, *Oecologia* 18: 185–197). Wilkund (*ibid*) suggests that the rareness and relatively recent introduction of the plant into Sweden may partially account for nonavoidance of the plant by ovipositing adults. The differences in larval feeding success between *polyxenes* of New York and Costa Rican populations may also be a function of the amount of time the plant and insect have been in contact. *Levisticum* does not, to our knowledge, occur in Costa Rica (Standley, P. C., 1938, *Flora of Costa Rica*, Field Mus. Natur. History, Chicago Botanical Series, Vol. 18 (no. 420); and Wm. Blau, *pers. comm.*).

In summary, we would like to emphasize the fact that foodplant utilization by *P. polyxenes* populations appears variable, depending upon local habitat factors and plant phenology in any particular year as well as regional or geographic host-plant preferences which may have evolved over a longer period of time. More field observations and laboratory studies could clarify many unknown or puzzling aspects of the coevolution of the Papilionidae and their hostplants.

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Journal of the Lepidopterists' Society
32(3), 1978, 239-240

BOOK REVIEW

THE BRITISH BUTTERFLIES, THEIR ORIGIN AND ESTABLISHMENT, by R. L. H. Dennis, 1977. E. W. Classey Ltd., Park Road, Faringdon, Oxon., England SN7 7DR. 318 pp., 20 figs., 15 tables. \$17.50 U.S.

Here is a book that should be of interest to all students of biogeography. It is well done but many general collectors of butterflies will find it hard going. First, it is not a book to help determine what species you have from the British Isles. It is a book that lives up to its second title. Dennis has divided his book into four sharply separate sections. North Americans may find the first part, "Geomorphological Framework" a bit puzzling at first. The table on p. 7 (the first page of the first chapter) sets forth the nomenclature used for the Pleistocene in northwestern Europe, including the British Isles. Add a third column to this, naming the equivalent North American terms, and you will be allright.

The other sections in sequence are "Recent Rhopalocera geography and habitat adjustments," "Subspecies and subspeciation," and lastly "The arrival sequence and establishment of the British Rhopalocera." In addition, there are four appendices containing useful information, particularly for those of us on this side of the ocean who lack intimate knowledge of the British fauna and flora.

The author has done an unusually good job assembling a wealth of data about the Pleistocene in the British Isles. He retells this in detail. It is best to have a good scale map of Great Britain and Ireland at hand unless you are intimately familiar with the geography of them. Maps would have helped in this section, but I suppose cost would have been prohibitive. In the second part of the book Dennis treats two subjects: zoogeography and adaptation to the environment. There is considerable redundancy, but it is not obtrusive. It may be helpful. Here is clearly demonstrated why the British Isles is the ideal place for such a study at this time. The region is essentially a closed system for butterflies with few migrants and substantial sea barriers. Collectors have been active for two centuries or more and their data are available. The region is small enough—a total area considerably less than the State of Montana. The amount of information about the area is greater than that for any comparable area in either Canada or the United States. This gives the zoogeographer an ample working sample. The geography side is equally well-reported. The ideas of geological mapping and stratigraphy and the foundation of modern geology are British inventions of the 18th century. Detailed large scale mapping is available for the entire United Kingdom. All of these are needed before such a task as Dennis set for himself can be confidently attacked.

The second half of the book, Sections C and D, contains an able discussion of subspeciation as evident in the British Isles. Dennis's interpretation of subspeciation, as related to geography, flora and modern and past climates, can be duplicated nowhere on the American continents. The last section is the interpretation of the data presented in the first three sections. Here Dennis had two earlier similar studies to use, and to agree or disagree with. He did all three. B. P. Beirne wrote several times on the subject and summed up his knowledge in *The Origin and History of British Macrolepidoptera* found in the *Trans. Roy. Entomol. Soc. Lond.*, 98, 1947. E. B. Ford set forth his views in detail in *Butterflies* published by Collins, London. The latest edition of this delightful book was released in 1957. Dennis had several advantages over either of these able authors. He had a large number of precise radiocarbon dates and the results of the very recent and extensive paleontological studies of Pleistocene and Recent (Flandrian) insects. Needless to say, Tables 14 and 15, setting forth the ideas of the three writers, show progressive changes in opinion. It will be a very long

time before a comparable work can be written for any part of the New World. This is a beautiful example of what can be done when data are available. The book is an important guide for those who would engage upon detailed zoogeographic studies.

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OBITUARY

JAMES H. BAKER (1910-1978)

Mr. James "Jim" Huffman Baker, charter member of the Lepidopterists' Society, died April 14, 1978 at St. Luke's Hospital in Boise, Idaho after a long illness. He was 67. Jim was born Aug. 14, 1910 in Baker, Oregon, the son of Deering F. and Bernice Huffman Baker. He graduated from Baker High School in 1928, was employed by the Citizen's National Bank in Baker, and then ran the family grocery, Baker's Supermarket, for over 35 years. Jim was a man of many activities. In addition to his lifelong interest in insects of many orders, he bowled, traveled, was interested in general nature study, collected rocks, and was an antique dealer and a gem worker.

He published several scientific papers, and his extensive collecting disclosed several insects that were subsequently named, including *Euphydryas anicia bakeri* Stallings and Turner, and *Celastrina argiolus bakeri* (Clench). He worked closely with both the American Museum of Natural History and the Smithsonian Institution. He was also a member of the Coleopterists' Society.

Jim will be greatly missed by all of his many friends and colleagues who have enjoyed his company and his family's hospitality. He is survived by his wife, Ilah; a son, James Michael Baker; a daughter, Judith Ann Haswell of Pullman, Washington; and two granddaughters.

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NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *duplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, $8\frac{1}{2} \times 11$ inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard, 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

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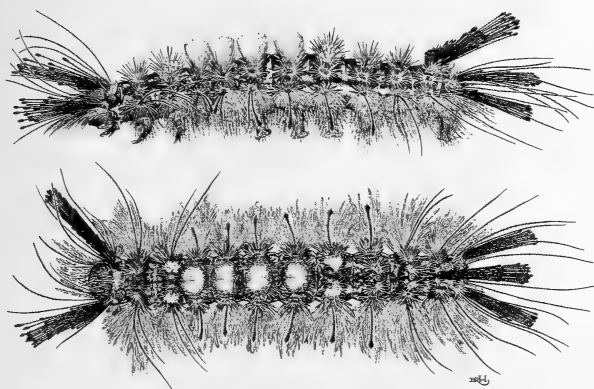
LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



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Cover illustration: *Dasychira dorsipennata* larva, dorsal and lateral views. From Fascicle 22.2, "Lymantriidae," by Douglas C. Ferguson, in *Moths of America North of Mexico*. The drawing was done by E. R. Hodges, Scientific Illustrator, Department of Entomology, Smithsonian Institution. (Reproduced by permission of the author.)

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 32

1978

Number 4

Journal of the Lepidopterists' Society
32(4), 1978, 241-250

THE ZALE SETIPES SPECIES COMPLEX (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT. The *setipes* complex of the noctuid genus *Zale* Hübner is revised. The identity of two species, confused for more than 100 years, is clarified. *Letis incipiens* Walker is removed from the synonymy of *Zale setipes* (Guenée) and elevated to a subspecies of *Z. peruncta* (Guenée). *Z. discisigna discisignata* Draudt is cited as new synonym of *Z. setipes* (Guenée) and *Z. setipes* ♀ f. *postmedialis* Draudt, *Homoptera aemona* Druce (in part), *Zale notipennis* Draudt are new synonyms of *Z. peruncta* (Guenée). The first United States record of typical *Z. peruncta* (Guenée) is listed.

The noctuid genus *Zale* Hübner, as currently recognized, is composed of a large number of moderately large moths, many with a rather similar pattern of cryptic wing maculation. The pattern of maculation is usually composed of numerous irregular transverse or oblique lines, the moths presumably resembling the bark of trees on which the moths may rest. They vary in color from nearly black to pale yellow brown or light gray. A few species, especially some from tropical America, have areas of pale green scaling on the wings, but that color usually fades very rapidly after death to yellow or yellow brown. Identification of species has been difficult in the past and many misidentifications have occurred. Two closely related species, *Zale setipes* (Guenée) and *Z. peruncta* (Guenée) have been confused, misidentified and misnamed since 1869. The purpose of this paper is to indicate the proper application of the names, to describe and illustrate the characters that distinguish the species, to detail the specific geographic distributions and to record *Z. peruncta* (Guenée) from the United States (Texas).

¹ c/o U.S. National Museum, Washington, D.C. 20560.

The two species are very similar in maculation and both species are sexually dimorphic, both males and females of each species more closely resembling the same sex of the other species than the opposite sex of their own species. The dimorphism is expressed in differences in the shape of the forewing and in the pattern of maculation. The males have a narrower forewing, somewhat produced apically, the termen nearly straight or even excavate before tornus, therefore differing from the females and the other species of *Zale* which have broad forewings and a rounded termen. The pattern of maculation of the males approaches that of some species of *Metria* Hübner (= *Safia* Guenée). The females resemble females of other *Zale* species in wing shape and maculation. Examples of *setipes* are consistently larger and have more pale scaling in the postmedial area of the forewing than do examples of *peruncta*. Excellent characters for specific separation exist in the male genitalia and in the shape of the sternal plate of the eighth abdominal segment of the female.

In 1965 the author studied the types and syntypes of *Metria* and *Zale* in the collection of the British Museum (Natural History) in order to correctly identify species from the Antilles and to obtain information necessary for possible future generic revisions. Nearly 80 slides of genitalia, mainly of types, were prepared and the errors in the application of the names, *Zale setipes* (Guenée) and *Zale discisigna* (Walker), were discovered. The types of all the names relating to the *setipes* complex, including the lectotype of *Z. peruncta* (Guenée) which was sent to me at that time from Paris, were studied.

HISTORY

Guenée described *Xylis setipes* (1852, p. 7, Noctuérites Pl. 15, Fig. 6) from a single male from Nova Friburgo, Brazil and *Homoptera peruncta* (1852, p. 9) from 2 specimens without locality. Guenée suggested that one specimen of *peruncta* was a male lacking antennae, but this seems unlikely since he placed the male of *setipes* in a separate genus, *Xylis* Guenée, while placing *peruncta* in *Homoptera* Boisduval with other typical *Zale* species. The lectotype of *peruncta* is a female specimen from the Paris Museum selected by Viette (1951, p. 161). The colored illustration of the type of *setipes* accompanying the original description is excellent.

For a number of years the relationship of *setipes* and *peruncta* and the sexual dimorphism in the complex were not recognized. During that period Walker described males of *peruncta* as *Homoptera ustipennis* ([1858] 1857, p. 1071) and *Letis incipiens* (1858, p. 1266). In 1869 (p.

157) Herrich-Schäffer identified specimens of *peruncta* from Cuba (true *setipes* is not known from the Antilles) as *Xylis setipes* Guenée and the trivial name has since been misapplied by all authors to date. In the collections of the U.S. National Museum and the British Museum (Natural History) the name was likewise misapplied. Möschler (1890, p. 202) listed females in his treatment of "*setipes*," but no discussion of sexual dimorphism was included. He did, however, wonder why the females he studied were only 42–45 mm in expanse whereas the size given for *setipes* in the original description was 55 mm. Butler (1879, p. 41) recognized that Walker's *ustipennis* was related to *setipes* in the statement: "*H. ustipennis*, a *Xylis*." There is no indication as to his specific concept of *setipes*. The sexual dimorphism of the complex had still not been recognized by Druce (1889, p. 341). He utilized *setipes* in the same sense as Herrich-Schäffer and listed *ustipennis* as a separate species from Panamá; both names were placed in *Xylis*. He did not refer to *Homoptera peruncta* Guenée. Females of both species of the complex obviously were present in his series of the new species, *Homoptera aemona*, because he stated: "The specimens from Guatemala are rather larger and are paler in colour than those from the Volcan de Chiriqui. Our figure is taken from one of these latter." In an unexplained action Hampson (1898, p. 250) placed *setipes* in *Polydesma* Boisduval and used *ustipennis* as a form of that combination for examples of *peruncta* from St. Lucia and Grenada. Hampson (1913, pp. 208–210, text figs. 54 and 55) treated both species and provided keys to and illustrations of the males. He placed the generic names *Homoptera* Guenée and *Xylis* Guenée in the synonymy of *Zale* Hübner. The two species of the *setipes* complex (as subgenus *Xylis*) were separated from the other species of *Zale* in the key because the hind tibiae of male are fringed with long hair and the hindwing with termen somewhat excurved at middle, the costa lobed [expanded] at the base. The type of *setipes* now in the British Museum (Natural History) was not available to Hampson as it was not received by that institution until 1928. Unfortunately, Hampson apparently did not check the original description and illustration of *setipes* and continued to use the name incorrectly for *peruncta* which he placed along with all other names of the complex in the synonymy of *setipes* as identified by him. Hampson made another error in treating true *setipes* by calling it *Zale discisigna* (Walker). He thought the worn, damaged female holotype of *Homoptera discisigna* Walker ([1858] 1857, p. 1066) represented the female sex of the large species of the complex. This error was perpetuated in collections and in the literature. *Homoptera discisigna* Walker does

resemble *setipes* somewhat and considering the condition of the type, the error is partially understandable, but *discisigna* is considerably smaller and is not even congeneric. The type of *discisigna* had been studied before by other workers and the species placed in *Peteroma* Schaus or *Barcita* Möschler in collections. Dognin apparently was confused by the use of *Homoptera discisigna* Walker for different species in collections and must have written to William Schaus about the problem. He attached a note from Schaus' reply of June 22, 1922 on a male of *peruncta* from Tucumán, Argentina now in the U.S. National Museum. Schaus informed him that he thought Walker had described two species named *discisigna* and that he believed that the one referable to *Peteroma* was described in "Characters of Lep. Het." Schaus obviously was wrong; no other description by Walker with the trivial name *discisigna* has been located. It seems likely that Schaus's belief in a second description probably developed because *discisigna* was originally described as a *Homoptera* and because Hampson applied the name to a *Zale* species.

SYSTEMATICS

Zale setipes (Guenée) (Figures 1-2, 9 and 12)

Xylis setipes Guenée, 1852, p. 7; 1858, Pl. 15 (Noctuélites), Fig. 6.—Walker, 1857, p. 1052.—Druce, 1889, p. 341 (in part).—Möschler, 1890, p. 202 (in part).

Zale setipes (Guenée), Draudt, 1940, Pl. 70, row b (*setipes* ♀).

Xylis ustipennis, Druce not Walker, 1889, p. 342 (in part).—Hampson, 1913, p. 208 (synonym of *discisigna*, Hmps.).

Homoptera aemona Druce, 1889, p. 344 (in part).—Hampson, 1913, p. 208 (synonym of *discisigna*, Hmps.).

Homoptera discisigna, Druce not Walker, 1890, p. 345 (in part).—Hampson, 1913, p. 208.

Zale discisigna, Hampson not Walker, 1913, p. 208, Fig. 54.—Haimbach, 1928, p. 216.—Draudt, 1940, p. 454 (in part).

Zale discisigna ab. *discisignata* Strand, 1917, p. 43 (= *discisigna* ab. 1 of Hampson. An infrasubspecific name, excluded.).

Zale discisigna discisignata Draudt, 1940, p. 455 (= *discisigna* ab. 1 of Hampson and ab. *discisignata* Strand.) [New synonymy.]

Diagnosis. Length of forewing, male, 24 to 27 mm, average 24.8 mm; female, 23 to 27 mm, average 24.2 mm. Pattern of maculation as illustrated (Figs. 1 and 2). Ground color of male paler than female and males of *Z. peruncta* (Guenée); transverse lines in medial area of forewing distinctly marked; **hindwing of male** with dark subterminal shade between veins M_3 and Cu_2 , reaching termen only at vein M_3 . Maculation of **hindwing of female** variable, with (Fig. 2) or without blue-white postmedial spots, ground color sometimes paler than females of *peruncta*, but usually about the same darkness. **Male genitalia** as illustrated (Fig. 9), apical process of ventral margin of valve rather sigmoid in shape, longer than the thin, rather rectangular apical process of costa of valve. Base of uncus with triangular (apex slightly



1



2



3



4



5



6

Adults of *Zale setipes* complex. Fig. 1, *setipes*, ♂, Chiriqui, Panama; 2, *setipes*, ♀, "Cent. Amer."; 3, *peruncta peruncta*, ♂, Juan Vinas, Costa Rica; 4, *p. peruncta*, ♀, Orizaba, Mexico; 5, *p. incipiens*, ♂, Cuba; 6, *p. incipiens*, ♀, Convento, Dominican Republic.

curved distad) lateral flanges; flanges present also on tegumen, bilobed, the depression between lobes variable in depth and caudal lobe sharp pointed (Fig. 9) or shorter and rounded (Noctuidae genitalia slide No. 5033 of holotype). **Female genitalia** (Fig. 12) with a pair of large rectangular sternal plates present below ostium.

Types. The HOLOTYPE, ♂, of *Xylis setipes* Guenée from Nova Friburgo, Brazil, Noctuidae genitalia slide No. 5033 and the HOLOTYPE of *Zale discisigna discisignata* Draudt, a ♀ from Volcan de Atitlan, [Guatemala], Noctuidae genitalia slide No. 5087, are in the British Museum (Natural History), London, England.

Distribution. The species is known to occur from Mexico to Brazil, but is not known from the West Indies. Specimens from the following localities have been examined. MEXICO: Jalapa; Orizaba. GUATEMALA: Volcan de Atitlan; Chejel; Cayuga; "Guatemala." COSTA RICA: Tuis; Juan Vinas. PANAMA: Chiriqui. COLOMBIA: Pacho, Ost-Cordill. ECUADOR: Jatunyacu, Oriente; Abitagua, Ori-

ente. BRAZIL: Castro, Parana; Rio Janeiro; Petropolis; "Casa Br."; Ponte Nova, Rio Xingu, Amazonas; Nova Friburgo.

Discussion. The larger size, paler ground color and distinctive male and female genitalia distinguish this species from *Z. peruncta* (Guenée).

Zale peruncta peruncta (Guenée)
(Figures 3-4, 8 and 11)

Homoptera peruncta Guenée, 1852, p. 9.—Walker, 1857, p. 1069.—Viette, 1951, p. 161 (Lectotype designation.).

Xylis setipes, Gundlach not Guenée, 1881, p. 358 (in part).—Druce not Guenée, 1889, p. 341 (in part).—Möschler not Guenée, 1890, p. 202 (in part).

Polydesma setipes, Hampson not Guenée, 1898, p. 250.

Zale setipes, Hampson not Guenée, 1913, p. 209, fig. 55 (*peruncta* (Guen.), *ustipennis* (Wlk.), *incipiens* (Wlk.) and *aemona* (Druce) as synonyms).—Wolcott not Guenée, 1923, p. 169; 1936, p. 432; 1951, p. 603.—Haimbach not Guenée, 1928, p. 216.—Draudt not Guenée, 1940, p. 455 (in part).—Schaus not Guenée, 1940, p. 229 (in part).—Biezanko, Ruffinelli and Carbonell not Guenée, 1957, p. 50.

Zale setipes ab. *postmedialis* Strand, 1917, p. 43 (= *setipes*, ab. 1 of Hampson. An infrasubspecific name, excluded.).

Zale setipes ♀ f. *postmedialis* Draudt, 1940, p. 455, pl. 70, row b (= *setipes*, ab. 1 of Hampson and ab. *postmedialis* Strand). [New synonymy.]

Homoptera ustipennis Walker, 1857, p. 1071. [New synonymy.]

Xylis ustipennis (Walker), Butler, 1879, p. 41.—Druce, 1889, p. 342 (in part).

Polydesma setipes f. *ustipennis* (Walker), Hampson, 1898, p. 250.

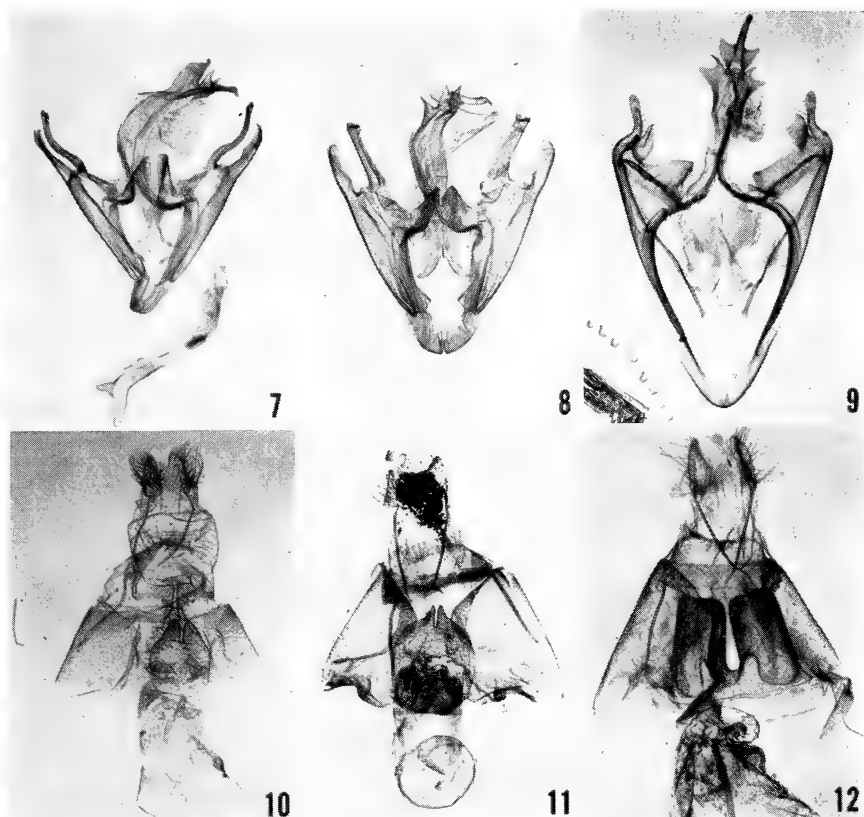
Homoptera aemona Druce, 1889, p. 344, pl. 31, fig. 3 (in part). [New synonymy.]

Zale discisigna, Draudt not Walker, 1940, pl. 70, row 6 (♂, *discisigna*).

Zale notipennis (sic) Draudt, 1940, p. 455 (misspelling of *ustipennis* Wlk. ? As synonym of *setipes*, Draudt). [New synonymy.]

Diagnosis. Length of forewing, male, 19 to 23 mm, average 20.4 mm; female, 19 to 23 mm, average 21.7 mm. Pattern of maculation of male (Fig. 3) similar to that of *setipes*, but ground color, particularly median part of forewing darker; dark subterminal shade of hindwing between veins M and Cu reaching termen for most shades width. **Female** marked and colored as in *setipes*, sometimes slightly darker, hindwing maculation variable as in *setipes*. **Male genitalia** with process from costa of valve longer than process from ventral margin, the latter slightly clavate or mitten-shaped, both processes (Fig. 8) quite different than in *setipes*. Flanges at base of uncus in typical subspecies nearly rectangular. Flanges of tegumen thornlike, apices slightly recurved. Sternal plate of **female genitalia** ovoid, caudal margin variable, usually terminating in two short bluntly pointed processes with a prominent narrow medial emargination (Fig. 11), occasionally emargination reduced in length, an extreme example with median caudal lobe that is very weakly emarginate (lectotype of *Homoptera aemona* Druce).

Types. The LECTOTYPE, ♀, of *Homoptera peruncta* Guenée, locality unknown, is in the Muséum National, Paris, France. The HOLOTYPE of *Homoptera ustipennis* Walker, ♂, locality unknown, Noctuidae genitalia slide No. 5091, and the SYNTYPES of *Homoptera aemona* Druce and *Zale setipes* f. *postmedialis* Draudt are in the British Museum (Natural History), London, England. Druce had examples of both this species and true *setipes* in his original series of *aemona* from Mexico, Guatemala, and Panama but did not indicate the number of examples either in total or from the respective countries. He illustrated a specimen, a ♀, from Volcan de Chiriqui, Panama. There are three specimens in the British Museum (Natural History) from that locality. One labeled *Homoptera aemona* Druce, Type ♀, Noctuidae genitalia slide No. 5090 has been selected and is presently designated as LECTOTYPE. The name



Male and female genitalia of *Zale setipes* complex. Fig. 7, *peruncta incipiens*, ♂; 8, *p. peruncta*, ♂ aedeagus not shown; 9, *setipes*, ♂ aedeagus not shown; 10, *p. incipiens*, ♀; 11, *p. peruncta*, ♀; 12, *setipes*, ♀.

postmedialis was proposed for "ab. 1" of Hampson who did not indicate number of specimens or locality. The specimen labeled as type, a female, Noctuidae genitalia slide No. 5088 from Grenada has been selected and is now designated **LECTOTYPE**.

Distribution. The typical subspecies occurs from southern Texas to Argentina on the continent and in the Antilles from Grenada to Puerto Rico. The specimen from Texas was collected on 27 November 1973 by A. and M. E. Blanchard. It represents a new record for the United States. I have examined specimens from the following localities. TEXAS: Santa Ana Refuge, Hidalgo Co. MEXICO: Jalapa; Misantla; Orizaba; Cordoba; San Cristobal las Casas, Chiapas. COSTA RICA: Tuis; Juan Vinas. PANAMA: Chiriqui. COLOMBIA: Sta. Marta. VENEZUELA: Aroa. ECUADOR: Abitagua, Oriente. BRAZIL: St. Catherines [Santa Catarina]; Alta da Serra, Sao Paulo; Rio Janeiro; Theresopolis. PARAGUAY: Sapucay; "Paraguay." ARGENTINA: Tucuman. GRENADA: Grand Etang; "Grenada." ST. VINCENT: Montreal District. ST. LUCIA: 1.5 mi S. Mt. Gimie; "St. Lucia." DOMINICA: Clarke Hall; Grand Savanne; Pont Casse. VIRGIN ISLANDS: Gallows Point, St. John. PUERTO RICO: 4 mi SE. Ciales; Ciales.

Discussion. This species is smaller than *setipes* and the ground color is slightly darker, especially the median area of the forewing and the subterminal spot between veins M_3 and Cu_2 . The two apical processes of the valve of the male genitalia and the sternal plate of the female genitalia are differently shaped than those structures in *setipes*. This subspecies may be separated from the other subspecies by area of occurrence and by characters of the male and female genitalia discussed in the diagnosis of the atypical subspecies. The species of the *setipes* complex of *Zale* do not appear to be common in most areas judging from the number of examples in collections and from my personal collecting experience. Only at Grand Etang, Grenada, to my knowledge, has a species of the complex been collected in large numbers (personal light trap collecting). Time of year, weather conditions, time of night, collecting locality, and collecting technique may in part explain the reduced captures elsewhere, but I believe some other factor is responsible. A few days later on St. Vincent and then on St. Lucia collecting with traps in apparently similar ecological locations resulted in only a few captured specimens. In a three year survey of Dominica, 1964–1966, eight different collectors collected only four examples of *peruncta*. It is true that traps were not utilized there and the species are also known to be only temporarily attracted to light, settling soon on the plants some distance away. However, I personally collected other species of *Zale* there in large numbers by collecting on such plants, the specimens located by their glowing, light reflecting eyes.

***Zale peruncta incipiens* (Walker), new status**
(Figures 5–6, 7 and 10)

Letis incipiens Walker, 1858, p. 1266.—Hampson, 1913, p. 209 (synonym of *setipes*, Hampson).—Schaus, 1940, p. 229 (synonym of *setipes*, Schaus).

Zale incipiens (Walker), Draudt, 1940, p. 455 (synonym of *setipes*, Draudt).

Xylis setipes, Herrich-Schaeffer not Guenée, 1869, p. 157.—Gundlach not Guenée, 1881, p. 358 (in part); 1891, p. 195.—Druce not Guenée, 1889, p. 341 (in part).—Möschler not Guenée, 1890, p. 351.—Ragués not Guenée, 1914, p. 141.

Xylis scitipes (sic), Anonymous not Guenée, 1895, p. 73 (misspelling of *setipes*).

Zale setipes, Hampson not Guenée, 1913, p. 209 (in part).—Schaus not Guenée, 1940, p. 229 (in part).

Diagnosis. Length of forewing, male, 18.5 to 20.5 mm, average 19.5 mm; female, 20.0 to 22.0 mm, average 21.2 mm. It seems likely that the range in size will probably approach that of the typical subspecies when more material is available for study. Only five pairs have been examined. The pattern of maculation appears to be essentially identical to that of *peruncta peruncta* and similarly variable. The male and female genitalia differ consistently from those of the typical subspecies. The apical processes of the valve of the male genitalia (Fig. 7) are more slender than in typical *peruncta*, the process of the costa distinctly sinuous. Flanges at base of uncus thornlike, each with apex bent caudad. Flanges of tegumen much larger, not thornlike in shape as in typical *peruncta*, apex variable in shape, up-curved and blunt (Fig. 7) or sharp-pointed and caudally directed (holotype). Female genitalia with sternal plate of eighth abdominal segment smaller than in typical subspecies, the caudal lobes larger in proportion to plate size (Fig. 10).

Type. The HOLOTYPE, ♂, from St. Domingo, Noctuidae genitalia slide No. 5089 is in the British Museum (Natural History), London, England.

Distribution. Known only from Cuba and Dominican Republic. The specimens studied are labeled as follows. CUBA: Santiago; Cayamas; "Cuba." DOMINICAN REPUBLIC: St. Domingo; San Francisco Mts., St. Domingo; Hotel Montana, 10 km NE Jarabacoa, La Vega Prov.; 1.3 km S Loma de Cabrera, Dajabon Prov.; Convento, 12 km S Constanza.

Discussion. The true status of this entity is not known. It has been placed as a subspecies of *peruncta* because of the geographic isolation and to express the close relationship of the two entities compared to *setipes*. At the present time *incipiens* and typical *peruncta* occur on the neighboring islands of Hispaniola and Puerto Rico respectively. The former population probably representing an old invasion from Central America, the latter a more recent invasion from northern South America through the Lesser Antilles.

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A LOST AND MISPLACED TAXON (LEPIDOPTERA: TORTRICIDAE)

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ABSTRACT. The rediscovery of "*Antithesia montana*" Bartlett-Calvert is recorded. Adult female genitalia are figured, and its assignment to the Tortricidae is established.

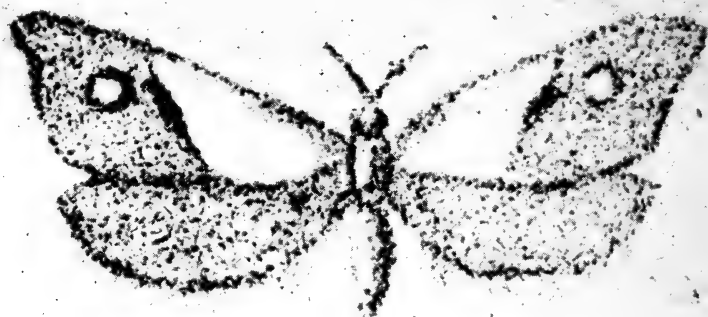
In 1893 (p. 831, Pl. 1, Fig. 4) Wm. Bartlett-Calvert described and figured *Antithesia montana* from Lolco, Araucania, Chile, without indication of its family connections. As far as I am able to ascertain, it was not until 1922 (p. 163) that the species was mentioned again, this time by Meyrick, when he placed the species in the Oecophoridae, in the genus *Hypercallia*. Obviously, Meyrick never saw the species, but based his placement on misinterpretation of the badly illustrated antennae, as the long labial palpi of *Hypercallia*.

In January 1974, Dr. Oliver S. Flint, Jr., Department of Entomology, Smithsonian Institution, rediscovered this species in Argentina, at Pucara, on the Rio Honthue so now it will be possible to establish more accurately its taxonomic position.

Bartlett-Calvert's type has disappeared; at least I have not been able to locate it. Dr. Ariel Camousseight, Chief, Sección Entomología, Museo Nacional de Historia Natural, Santiago informed me that the type is not in that museum, and Dr. Klaus Sattler, of the British Museum (Natural History), where some of Bartlett-Calvert's material was deposited, informed me that *montana* is not represented in that collection.

"Lolco, Araucania" is given as the type locality. "Araucania . . . was the name of a former region of Chile . . . now mainly comprised in the provinces of Arauco and Valdivia." Lolco, however, is now in the province of Malleco. The specimen before me, collected by Dr. Flint, came from Pucara, just over the border between Argentina and Chile. Pucara is situated approximately 225 km south of Lolco and 25 km west of San Martin de los Andes.

The original description in Spanish is as follows: "Las alas anteriores, por encima con la mitad basilar amarilla; la mitad externa i una parte de la base negruzca, o con reflejos de luz rojizo-negruzco; en el centro de la mitad externa hai una mancha redonda amarilla, encerrada por un círculo negro; las posteriores de un color moreno-negruzco bril-



1

4



2

Figs. 1-2. *Proculia montana* (Bartlett-Calvert). 1, reproduction of the original figure; 2, from Argentina, Pucara.

liante; por de bajo, todas las alas son morenas inclinaándose a negro; la cabeza de color amarillo; el torax i abdómen moreno oscuro; las franjas en las alas anteriores son negruzcas i en las posteriores moreno-claras."

A free translation of the above follows:

"The forewings above from center to base yellow; the outer half and part of the base dark brown, or with reflections of reddish brown; in the center of the outer half there is a round yellow spot contained by a black circle; the hindwings of a shining tawny dark brown; the undersides of all the wings are brown inclining to black; the head yellow; the thorax and abdomen dark brown; the fringes of the forewing are dark brown and in the hindwings clearly brown."

The description fits the specimen in hand and needs no emendation. The female genitalia are described below for the first time. No male is available.

Genus *Proeulia* Clarke

Proeulia Clarke, 1962, Proc. Biol. Soc. Washington, 75, 293-294 (Type species.—*Eulia robinsoni* Aurivillius, in Skottsberg, The Natural History of Juan Fernandez and Easter Island, 3: part 2, 266, Pl. 11, fig. 17).

Proeulia montana (Bartlett-Calvert), new combination

Antithesia montana Bartlett-Calvert, 1893, Santiago de Chile, Univ. Anales, 84:831, Pl. 1, Fig. 4.

Hypercallia montana (Calvert), Meyrick, 1922, In Wytsman, Genera Insectorum, 180: 163.

Male genitalia unknown.

Female genitalia (USNM 24331). Ostium very broad, strongly sclerotized inwardly. Antrum not differentiated from the strongly sclerotized, very short ductus bursae. Bursa copulatrix membranous without ventral sclerotized process. Ductus seminalis from latero-ventral surface of bursa copulatrix.

Type. Lost.

Type locality. Chile, Malleco, Lolco.

Distribution. Chile, Argentina.

Foodplant. Unknown.

Remarks. Although this species lacks one feature characteristic of the genus *Proeulia*, the sclerotized process from the ventral surface of the bursa copulatrix, I do not hesitate to place *montana* in this genus. As pointed out by Obratzsov (1964), "Only in the description of the wing venation are some modifications necessary." He points out that veins 6 and 7 of the hindwing are sometimes slightly separate, as opposed to being stalked, as originally described; also that veins 3 and 4 of hindwing "are either connate or slightly separate at origin" the latter condition found in *montana*. Obratzsov also points out that the peculiar process from the ventral surface of the bursa copulatrix is reduced in some species, and speculates that it might disappear in some taxa. In the case of *montana* this process is absent, as predicted by Obratzsov.

Since the identity of this species appears to be beyond doubt, the designation of a neotype is not necessary.

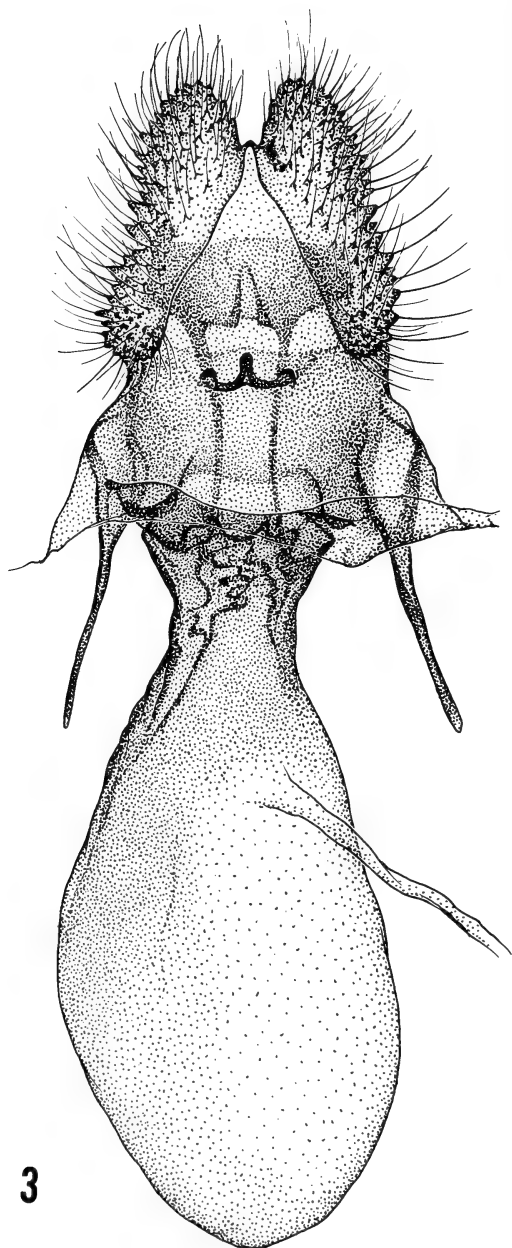


Fig. 3. *Proeulia montana* (Bartlett-Calvert), ventral view of female genitalia.

ACKNOWLEDGMENTS

The photographs were made by Victor E. Krantz, and the drawing of the genitalia was made by Mr. George Venable, both on the staff of the Smithsonian Institution.

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LARISA SUBSOLANA, A NEW GENUS AND SPECIES OF MOTH FROM EASTERN NORTH AMERICA (OLETHREUTIDAE)

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ABSTRACT. *Larisa* Miller, new genus, is proposed for *Larisa subsolana* Miller, new species. *Larisa* is intermediate between the subfamilies Laspeyresinae and Eucosminae but is tentatively placed in the former. *Larisa subsolana* is described from more than 130 adult specimens representing a geographic range from Texas and Florida north to Michigan, Ontario, and Massachusetts. Capture dates in Florida range from March 14 to September 27; elsewhere April 10 to August 7.

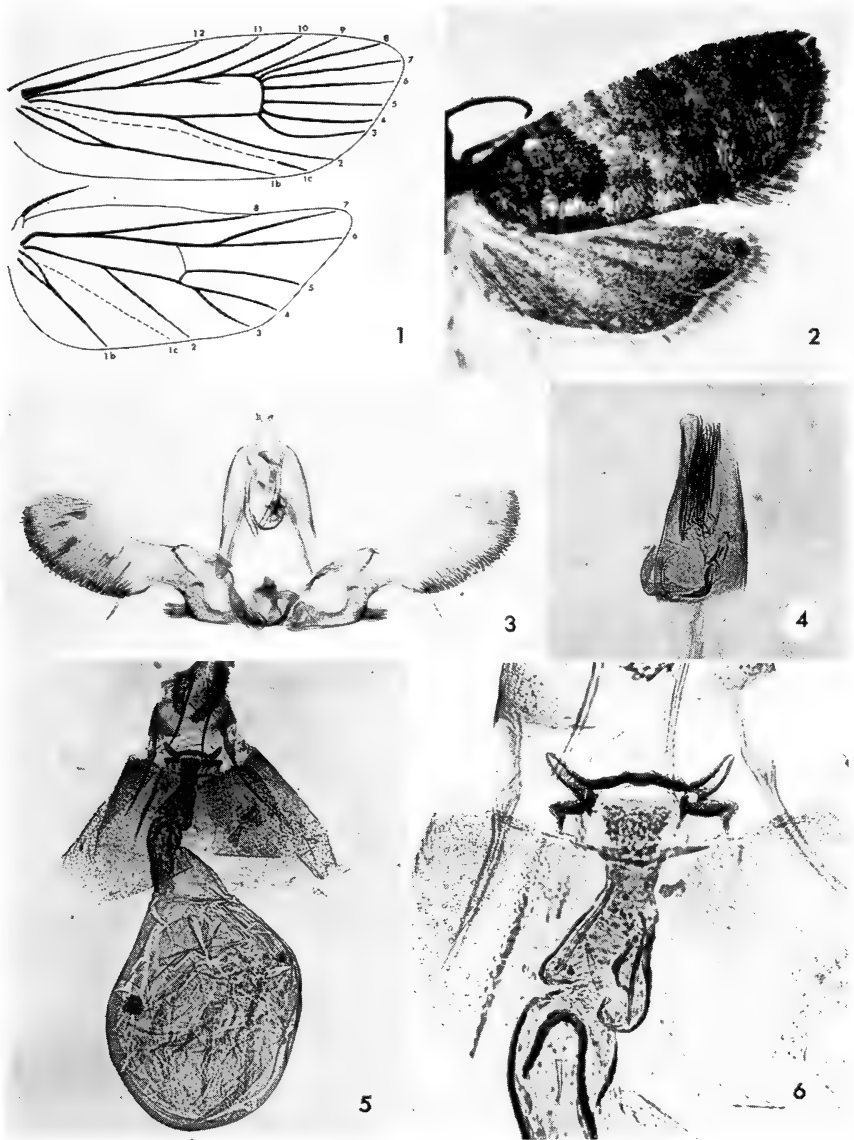
I have noticed the species discussed here in museums and private collections for a decade. It was sometimes identified as *Epinotia*, *Gypsonoma*, or *Laspeyresia*, genera which represent two olethreutid subfamilies. Detailed study eventually showed that the species cannot be placed in any existing genus. This report is based on more than 130 adult specimens. The letter *n* denotes number of observations or specimens underlying a particular statement.

Larisa Miller, new genus

Male and female. **Head:** Maxillary palpus with two developed segments (3 *n*); labial palpus slightly upturned, second segment expanding apically; antenna $2/5 \times$ forewing length; scaling of front and crown dense, bushy. **Thorax:** Smooth-scaled; metathoracic legs unmodified. **Forewing:** Smooth-scaled; slightly broader toward termen; costal fold absent; costa slightly and uniformly curved from base to apex; apex acute; termen convex; dorsum curved; 12 veins, all separate, upper internal vein of cell arising between veins 10 and 11, vein 11 arising near middle of cell (Fig. 1, 5 *n*). **Hindwing:** Costa convex near middle; apex acute; termen concave; dorsum straight between veins 1b and 3; pecten normal; veins 3 and 4 stalked to almost connate; vein 5 straight or slightly bent at base toward 4; veins 6 and 7 stalked (Fig. 1, 5 *n*). **Abdomen:** Smooth-scaled; eighth segment of male with a pair of lateral scale tufts; eighth tergite of female with scales as well as setae. **Male genitalia:** Uncus well developed, sclerotized and bifid; gnathos fused ventrally across middle; hami long, finger-like; valva simple with rudimentary clasper, a tuft of fine setae on base of sacculus; one to several long, slender setae may be present on latero-ventral surface of cucullus; aedeagus sleeve-like, short, tapered; deciduous cornuti present; dorsal plate of anellus not developed. **Female genitalia:** Papillae anales simple; posterior apophyses slightly longer to slightly shorter than anterior apophyses; sterigma shield-shaped with short finger-like projections beside ostium, ostium on anterior margin; ductus bursae short, enlarged near middle, sclerotized except for a short distance beyond enlargement, convoluted at junction with corpus bursae; dual thorn-like signa.

Type-species. *Larisa subsolana*, new species.

Comments. *Larisa* keys to Laspeyresinae or Eucosminae (Heinrich 1923, Obraztsov 1958) depending on character variability and interpretation. It is an intermediate genus but is tentatively placed in Laspeyresinae. In the male, the



Figs. 1-6. *Larisa subsolana*, new species. 1, Venation of fore- and hindwing. 2, Fore- and hindwing of specimen from Devil's Den State Park, Arkansas. Length of forewing 5.0 mm. 3, Male genitalia of specimen from 3 km E Palmdale, Florida. 4, Enlargement of aedeagus of preceding male. 5, Female genitalia of specimen from preceding locality. 6, Enlargement of sterigma and associated structures of preceding female.

rudimentary clasper and well developed uncus are characteristic of Eucosminae. Within Laspeyresinae, *Larisa* most resembles *Laspeyresia* and *Hemimene* or *Pammene* (Heinrich 1926, Obraztsov 1960) but differs from both by its convex forewing termen, long setae on outer surface of cucullus, setal tufts on sacculus, well developed hami, and in previously enumerated details of forewing or hindwing venation. *Larisa* is feminine gender and a patronym for Larisa K. Miller, my volunteer assistant.

Larisa subsolana Miller, new species

Male. Length of forewing 3.8–5.8 mm (71 *n*). **Head:** Labial palpus brown, scales white-tipped, length of second segment $1 \times$ eye diameter and $2.9\text{--}4.0 \times$ length of apical segment as estimated from scaled and descaled specimens (21 *n*); front and crown light brown; antenna brown. **Thorax:** Brown dorsally, including tegula, scales white-tipped; shining white ventrally; pro- and mesothoracic legs brown on outer side, scales white-tipped, tarsi white-banded, shining white on inner side; metathoracic legs shining white. **Forewing** (Fig. 2): Length $2.6\text{--}2.9 \times$ width (5 *n*); ground color of upper side brown; basal patch sharply delineated; middle crossband grayish brown grading apically to darker brown, a thin brown line centrally from costa to dorsum; distal third grayish brown, tinged in costal half with rust; fringe brown; underside light brown, mottled with white in costal area. **Hindwing** (Fig. 2): Widest membranous part $1.1\text{--}1.4 \times$ that of forewing (5 *n*); upperside, underside, and fringe light brown. **Abdomen:** Grayish brown dorsally, paler ventrally, including genital scaling. **Genitalia** (Figs. 3–4): Width of valval neck $0.43\text{--}0.74 \times$ greatest width of cucullus (24 *n*), the individual values showing a normal frequency distribution; 8–17 deciduous cornuti or empty cornutus sockets (12 *n*).

Female. As described for male except forewing length 4.1–6.3 mm (61 *n*) and brown genital scaling. **Genitalia** (Figs. 5–6, 20 *n*): Sterigma with short finger-like projections lateral to ostium bursae; posterior apophyses slightly longer to slightly shorter than anterior apophyses.

Types. HOLOTYPE ♂: ARKANSAS, Devil's Den State Park, Washington Co., June 26, 1966 (R. W. Hodges), No. 72093 in National Museum of Natural History. ALLOTYPE ♀: ARKANSAS, same data as holotype except May 30, 1966, in National Museum of Natural History. PARATYPES, 10 specimens: ARKANSAS, same data as holotype except 22 May 1966, ♂ genitalia slide USNM Tor 2, wing slide WEM 5; same data as holotype except 20 May 1966, ♂ genitalia slide LKM 1219766; 13 km SE Ethel, Arkansas Co., 9 July 1969 (R. L. Brown); MISSISSIPPI, Clinton, Hinds Co., 14 July 1974 (Bryant Mather), No. 73267, ♀ genitalia slide LKM 403772; MICHIGAN, East Lansing, Ingham Co., 15 July 1968 (J. P. Donahue), ♂ genitalia slide JAB 34; T4N, R2W, Sec. 35, Ingham Co., 12 June 1966 (J. P. Donahue), ♂ genitalia slide KAK 73; ALABAMA, 21 km SW Greensboro, 23 April 1976 (J. B. Heppner); FLORIDA, 3 km E Palmdale, 4 May 1974 (J. B. Heppner), ♀ genitalia slide JBH 455; same data as preceding except ♂ genitalia slide JBH 454; NEW YORK, Ithaca, 2 July 1976 (J. G. Franclemont), ♀ genitalia slide RLB 645. Paratypes are in National Museum of Natural History; California Insect Survey, University of California, Berkeley; Florida State Collection of Arthropods; Cornell University; University of Minnesota, Twin Cities; and collections of Richard L. Brown, John B. Heppner, and Bryant Mather. Specimens not designated as paratypes are in the above repositories, also University of Michigan and Field Museum of Natural History.

Geographic distribution. Present records for the species occur from Texas and Florida north to Michigan, Ontario, and Massachusetts (Fig. 7).

Biology. Available biological information is based on adults captured in flight. The hostplant is unknown. There is probably more than one generation a year. Capture dates in Florida range from March 14 to September 27 (20 *n*); elsewhere,

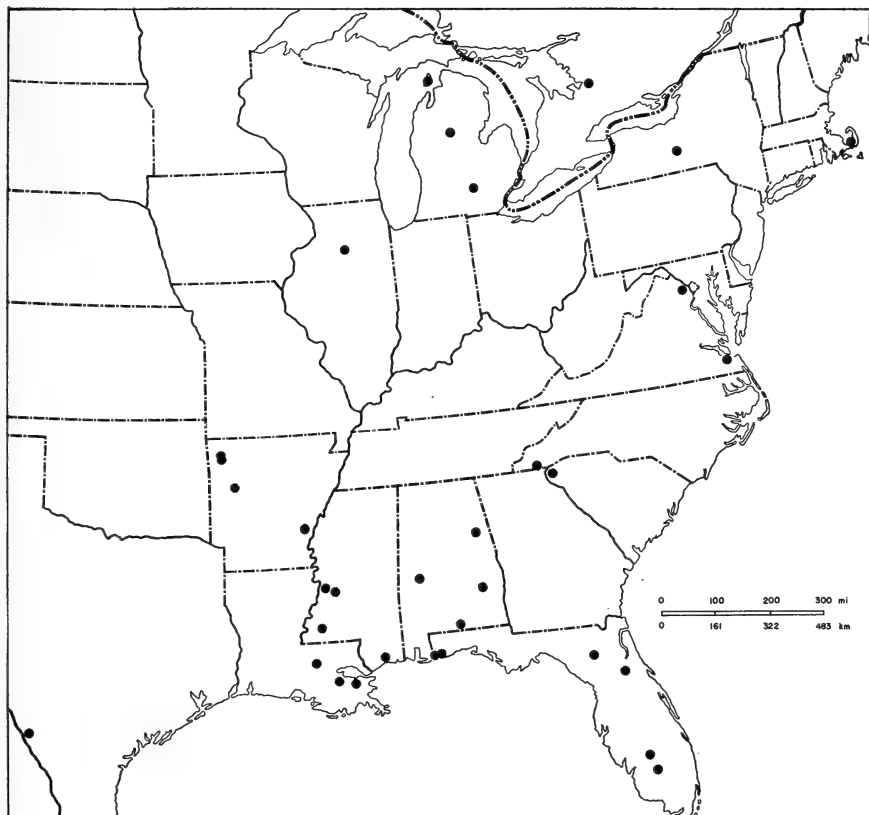


Fig. 7. Distribution of records for *Larisa subsolana*.

April 10 to August 7 (116 *n*). If the largest sample of moths from one locality (46 *n*, Devil's Den State Park, Arkansas, 20 May–22 July 1966, R. W. Hodges) represents one generation, the flight period is longer than that of many olethreutids and suggests a protected place of development insulated by shade, soil, or woody tissue. This sample also shows protandry typical of olethreutids (the median capture date of males preceding that of females by 12 days) and a male/female ratio of 0.92, essentially unity.

ACKNOWLEDGMENTS

I thank the following for specimen loans and other assistance: Jerry A. Powell, University of California, Berkeley; Don R. Davis, National Museum of Natural History; Roland L. Fischer, Michigan State University; Thomas E. Moore, University of Michigan; Bryant Mather, Clinton, Mississippi; Charles P. Kimball, West Barnstable, Massachusetts; and Henry Dybas, Field Museum of Natural History. I am espe-

cially indebted to Richard L. Brown, Cornell University, and John B. Heppner, University of Florida. After more than 50 *Larisa* specimens had come to my attention, I prepared a draft of this paper and asked several workers including Brown and Heppner to review it. Unknown to me, both were also independently studying the insect and each generously forwarded research information and more than 60 additional specimens to me.

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NOTES ON MEXICAN ACTINOTE (NYMPHALIDAE: ACRAEINAE) AND THEIR RELATIVES, WITH DESCRIPTION OF A NEW SUBSPECIES

JACQUELINE Y. MILLER AND LEE D. MILLER

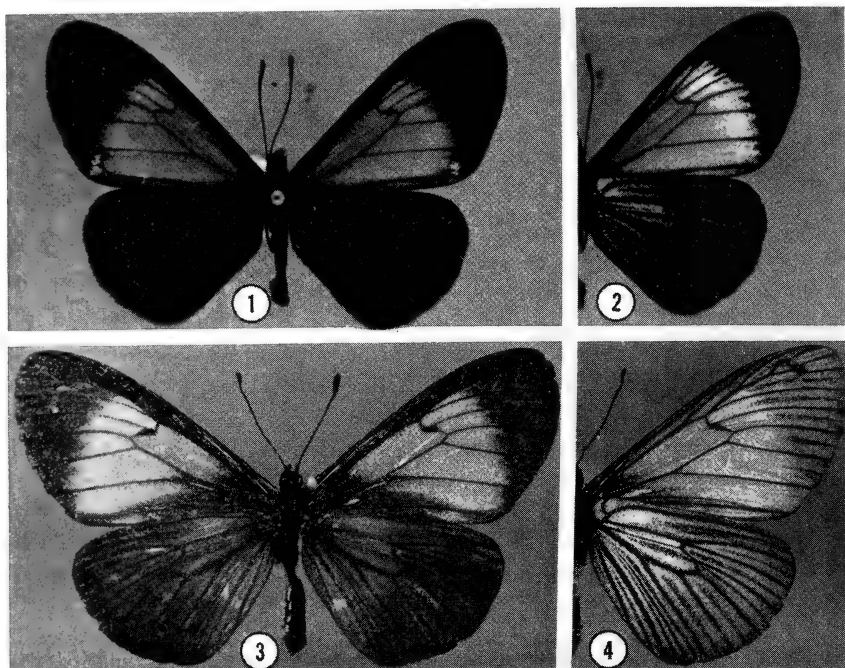
Allyn Museum of Entomology, 3701 Bay Shore Road, Sarasota, Florida 33580

ABSTRACT. The application of names described for South American species to their Central American, and especially Mexican, counterparts has led to great confusion in the literature. *Actinote stratonice oaxaca* is described from Oaxaca, Mexico; this insect had been reported previously as the nominate subspecies. Three species of the *Actinote thalia* group, *A. calderoni*, *lapitha* and *thalia* are illustrated, redescribed and discussed. A key for the separation of the three species is provided. The first two species are recorded from Mexico—*calderoni* had been previously misidentified as *lapitha* from there. One name, *A. lapitha zilchi* Franz and Schröder, is synonymized to *calderoni*.

Collecting in Mexico over the past forty years has yielded many butterfly species that were previously unknown from there, not a few of which were totally unexpected. These unexpected taxa have created many problems, usually for one of two reasons: 1) the butterfly was an already described Central or South American species and was described as new from Mexico because of a lack of comparative material or an ignorance of the pertinent literature; or 2) many species (especially those figured and described in *Seitz*) incorrectly have been ascribed to the Mexican fauna, again because of a lack of adequate comparative material. Both situations are well demonstrated in the Nymphalidae: Acraeinae. The Hoffmann (1940) catalog lists only four species of this subfamily within the borders of Mexico, but recent collecting has uncovered one that has been misidentified in collections and in correspondence—the one with which the first-mentioned species had been confused and an undescribed subspecies of a well-known South American insect. In the hope of unravelling the confusion in this small subfamily (within the Mexican borders), we offer these notes.

Actinote stratonice oaxaca J. Miller and L. Miller, new subspecies Figs. 1-6

Male. Head, thorax and appendages black; abdomen black with a reddish-brown midsternal line. **Upper surface of wings** similar to that of the nominate subspecies, but paler, and with the following differences: forewing totally black anteriorly of cell (partially reddened in other subspecies); dark marking at end of forewing cell much smaller than in other subspecies and black area at base of forewing cell and along inner margin more restricted than in other populations. **Under surface pattern** also paler than in *s. stratonice* with forewing differences as noted for upper surface



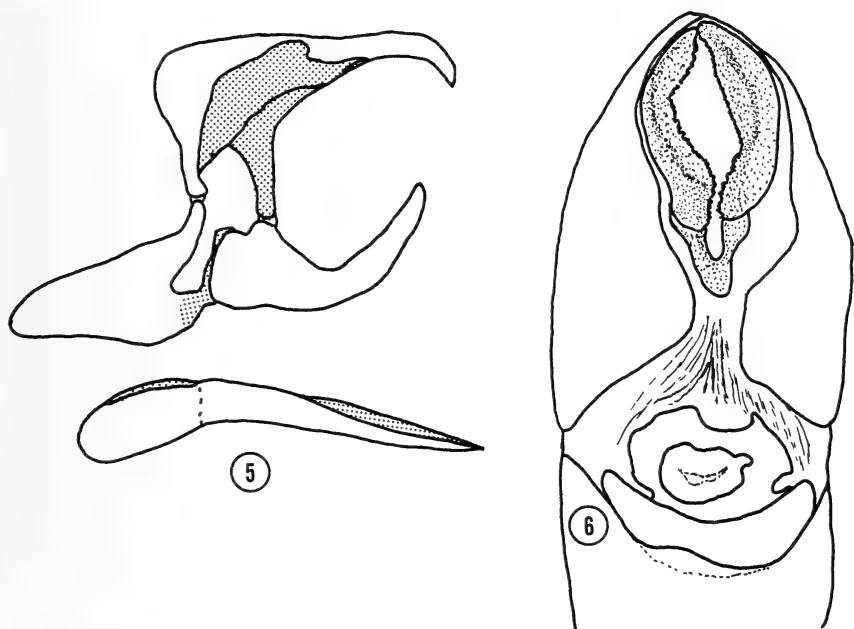
Figs. 1-4. *Actinote stratonice oaxaca* J. Miller and L. Miller, new subspecies. 1-2, Holotype ♂, upper (1) and under (2) surfaces; MEXICO: OAXACA: Candelaria Loxicha, 550 m. 3-4, Paratype ♀, upper (3) and under (4) surfaces; same locality. Both specimens in Allyn Museum of Entomology.

and in addition the pale orange patches in the forewing cell area darkened basad, blending to tawny-yellow distad; black areas admixed with pale yellow scales, especially in base hindwing. ♂ **genitalia** as illustrated, differing from those of other *stratonice* in only minor respects. **Length of forewing** of Holotype ♂ 24.4 mm, those of eleven of the ♂ Paratypes range from 26 to 31 mm.

Female. Differs from the ♀ of nominate *stratonice* in the same manner as does the ♂, but additionally the basal black areas of the forewing encompass the proximal third of the cell and below it along the inner margin, and all of the black areas below are completely suffused with yellow scaling. One ♀ Paratype has a hindwing supernumerary vein off Rs on the right side. ♀ **genitalia** as illustrated and comparing well with those of other subspecies. **Lengths of forewings** of 12 ♀ Paratypes range from 28.2 to 38 mm.

Specimens examined. Described from 25 specimens, 13 males and 12 females, from the state of Oaxaca, Mexico.

Types. HOLOTYPE ♂: MEXICO: OAXACA: Candelaria Loxicha, 550 m, 8.ix.1969 (E. C. Welling). PARATYPES: all MEXICO: OAXACA: same locality as Holotype, 1♂ 15.xi.1967, 1♂ 15.ix.1968, 1♀ 21.vii.1970, 1♂ 1♀ 27.viii.1970, 1♀ 21.vii.1973 (all E. C. Welling M.); El Portillo del Rayo, Candelaria Loxicha, 1♂ 3♀ 17.xi.1967 (all E. C. Welling M.), 6♂ 4♀ 18.vii.1976 (all de la Maza family); Rio Molina, Mpio. Suchistepec, 2200 m., 1♀ 10.x.1967 (E. C. Welling M.); San Jose Pacifico, Mpio. Rio Hondo, 2400 m., 1♂ 9.x.1967 (E. C. Welling M.); Puente



Figs. 5-6. *Actinote stratonice oaxaca* J. Miller and L. Miller, new subspecies. 5, ♂ genitalia of Paratype; MEXICO: OAXACA: Candelaria Loxicha; preparation M-3630 (Jacqueline Y. Miller). 6, ♀ genitalia of Paratype; same locality; preparation M-3602 (Jacqueline Y. Miller).

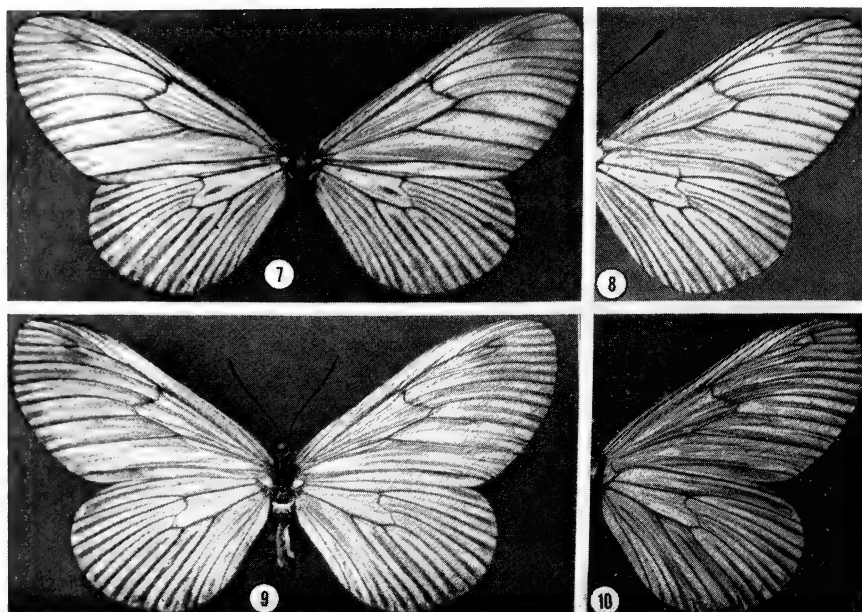
del Guajolote, Jalatengi, 1 ♀ 21.iii.1975 (E. Fernandez), 1 ♂ 21.xi.1975 (de la Maza family); Dos de Mayo, 1 ♂ 18.v.1976 (de la Maza family).

Disposition of type series: Holotype ♂, two ♂ and four ♀ Paratypes in the collection of the Allyn Museum of Entomology; two ♂ and three ♀ Paratypes in the collection of E. C. Welling M. and eight ♂ and five ♀ Paratypes in the de la Maza collection.

Remarks. The subspecific name refers to the state from whence the new subspecies came.

A. stratonice is recorded in Seitz from the Sierra Madre de Santa Marta of Colombia and southward through the mountains of Venezuela and into Ecuador. The present subspecies was first recorded in the literature from Mexico by de la Maza R. and de la Maza E. (1975), but at the time they did not recognize it as a separate subspecies.

The subspecies *oaxaca* is characterized by its overall dull coloration and by the suffusion of the under surface with pale yellow scales. In none of the other subspecies of *stratonice* do these characters appear. The disjunct distribution of *stratonice*, with a Mexican subspecies widely separated from its nearest relatives, is indeed intriguing.



Figs. 7-10. *Actinote calderoni* Schaus. 7-8, ♂, upper (7) and under (8) surfaces; MEXICO: CHIAPAS: Mapastepec. 9-10, ♀, upper (9) and under (10) surfaces; same locality. Both specimens in Allyn Museum of Entomology.

The Identity of the Mexican *Actinote thalia* Group Species

Pale Mexican specimens of *thalia* group *Actinote* in most collections usually have been identified as *A. lapitha* (Staudinger). Comparison of most Mexican material with Staudinger's description and subsequent literature citations suggest that these specimens could not be true *lapitha*. Accordingly, we searched museum and private collections and the literature for documented material that might shed light on the correct name for the Mexican insects. The results were surprising, and to avoid future confusion the following redescriptions are offered to aid in the identification of these butterflies.

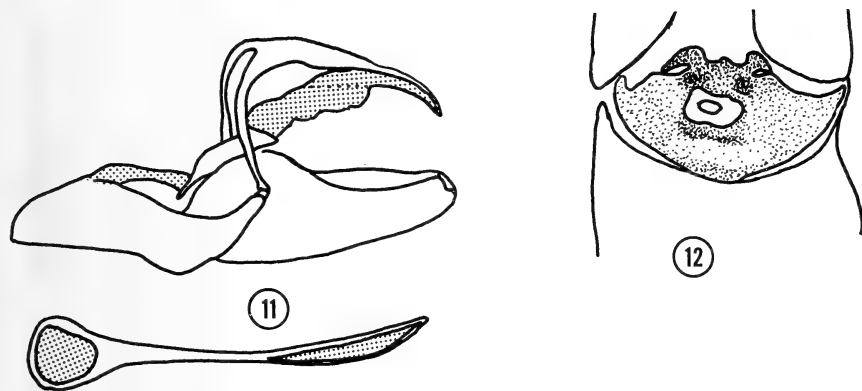
Actinote calderoni Schaus, 1920

Figs. 7-12

Actinote calderoni Schaus, 1920: 434 (TL—Anteos, El Salvador).

= *Actinote lapitha zilchi* Franz and Schröder, 1954: 80; fig. 2 (TL—Km. 30, Sonsonate Rd., La Libertad, El Salvador). [New Synonymy.]

Male. Head, thorax and first two **abdominal segments** dark brown covered with a few fuscous and tawny dorsal hairs; remaining **abdominal segments** naked



Figs. 11-12. *Actinote calderoni* Schaus. 11, ♂ genitalia; MEXICO: CHIAPAS: Mapastepec; preparation M-3633 (Jacqueline Y. Miller). 12, ♀ sterigma; same locality; preparation M-3601 (Jacqueline Y. Miller).

dorsad; thorax and first two abdominal segments covered with a few tawny ventral scales; last abdominal segments ventrally naked; pleural line buff. Palpi tawny with a few black scales along inner surface only. Antennae and legs black.

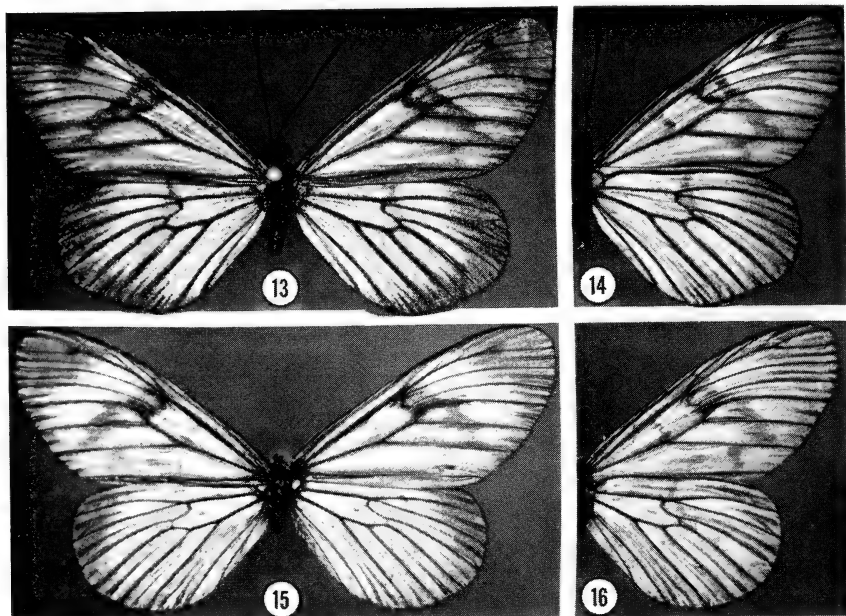
Upper surface of wings very thinly scaled with white, giving a dusky, off-white appearance; forewing smoky at apex and marginally to Cu_2-2A ; veins slightly darkened and interneural spaces with single smoky stripes. **Under surface of wings** similar, but a faint, dark comma-shaped marking lies from M_2-Cu_1 to Cu_1-Cu_2 of the forewing and numerous long, dark hairs lie on the veins, especially of the hindwing. ♂ **genitalia** as illustrated. **Forewing lengths** of the ♂ examples examined range from 21.5 to 24.5 mm.

Female. Similar to ♂, but paler, especially the forewing smoky markings above and below. ♀ **genitalia** as illustrated, generally characterized by having the sterigma more sculptured than in related species. **Lengths of forewings** of ♀ specimens at hand range from 25 to 30.5 mm.

Types and specimens examined. We have examined 15 specimens, seven males and eight females, from the following localities: EL SALVADOR: Anteos, 1 ♂ (HOLOTYPE, USNM), 1 ♂ (possible PARATYPE, CM). GUATEMALA: Tiquisate, 28.vi.1947, 1 ♀ (AMNH). MEXICO: CHIAPAS: Mapastepec, various dates, 1939-1959, 2 ♂ 5 ♀ (AME), 3 ♂ 1 ♀ (AMNH); San Jeronimo, 600 m., 17.vii.1975, 1 ♀ (E. C. Welling M.).

The records from Mexico and Guatemala are apparently the first for either country. The present insect has been masquerading in Mexican collections for years as *A. lapitha* (Staudinger), a species that is abundantly distinct.

Not only have workers on Mexican butterflies been confused on the identity of *calderoni*, but also those in other parts of Central America. The fact that Schaus' (1920) description appeared in an entomologically obscure journal has resulted in the paper never being cited previously by workers on *Actinote*. Were the "Fifty-Year Rule" still in effect in



Figs. 13–16. *Actinote lapitha* (Staudinger). 13–14, ♂, upper (13) and under (14) surfaces; MEXICO: CHIAPAS: Tierra Blanca, Mpio. La Trinitaria, 1500 m. (E. C. Welling M. collection). 15–16, ♀, upper (15) and under (16) surfaces; no locality data (AMNH collection).

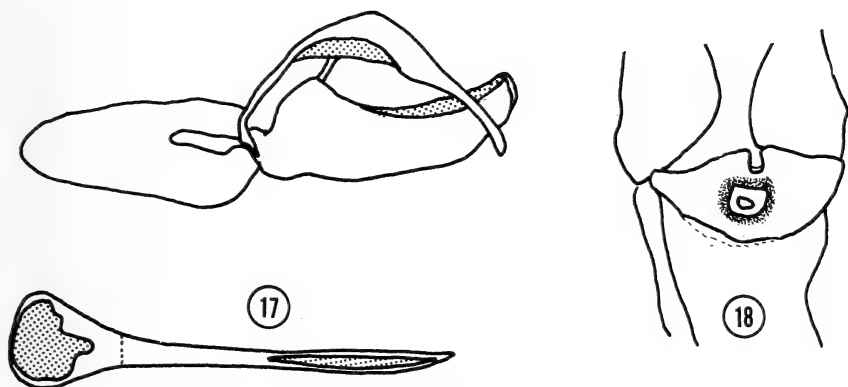
the *International Code of Zoological Nomenclature*, the name *calderoni* could be ignored with impunity, but happily this rule was repealed a few years ago, so we must return to the oldest name. Franz and Schröder (1954) had obviously not seen the Schaus description, but their excellent figure of the type of *A. lapitha zilchi* is referable to specimens of *calderoni* that we have seen (including the Holotype), and since the two taxa were described from within 100 km. of one another, it is evident that they represent the same species.

Actinote lapitha (Staudinger), 1888

Figs. 13–18

Acraea lapitha Staudinger, 1888: 82 (TL—"Chiriqui").

Male. Head, thorax and abdomen clothed with black dorsal hairs; head, palpi and most of thorax also clothed with black ventral hairs; small patch of tawny scales on meso- and metathoracic preepisterna and an additional such patch on metathoracic epimeron; abdomen clothed with admixed fuscous, tawny and buff scales; pleural line tawny and buff only. Antennae and legs black. Ground color of forewing above translucent and tawny with margins outlined in dull gray-brown, especially at apex; prominent gray-brown transverse marking from end cell to Cu_2-2A , interspersed with



Figs. 17-18. *Actinote lapitha* (Staudinger). 17, ♂ genitalia; MEXICO: CHI-APAS: Tierra Blanca, Mpio. La Trinitaria; preparation M-3416 (Jacqueline Y. Miller). 18, ♀ sterigma; no data; preparation M-1657 (Jacqueline Y. Miller).

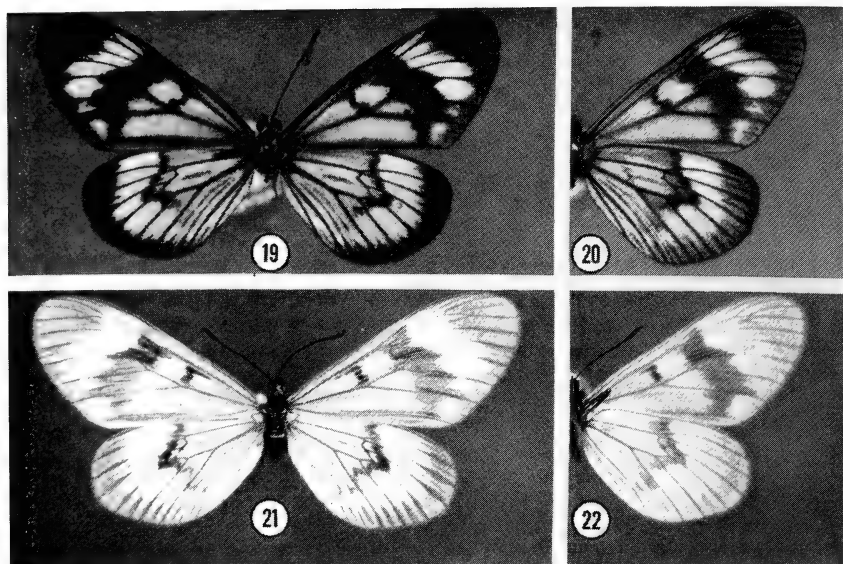
tawny scaling from end cell to M_3 - Cu_1 ; veins and interneural striping prominent, gray-brown. **Hindwing above** also translucent tawny, dull gray-brown at costa and along margin; veins heavily darkened with gray-brown and interneural markings of same color short and heavy. **Forewing below** similar to upper surface, but margins and apex not so dark and with an additional dull gray-brown bar across middle of cell. **Hindwing below** as above with a faint gray-brown cell end marking from costa to base of M_3 and more prominent veinal and interneural blackish-brown striping. Fringes of both wings blackish on both surfaces. ♂ **genitalia** as illustrated. **Lengths of forewings** of the three ♂ specimens examined range from 22.8 to 23.6 mm.

Female: Similar to ♂, but thorax sparsely clothed with tawny scales, markings of all wings paler, but extra-discal band of forewing more prominent and base of cell of same wing somewhat overscaled with fulvous. ♀ **genitalia** as illustrated; sterigma somewhat heavier than that of the next species and not quite so ornamented as in *calderoni*. **Lengths of forewings** of the two ♀ examples before us 20.2 and 23.1 mm.

Types and specimens examined. We have seen two females and three males of this insect. PANAMA: Jicaron Island, 14-15.i.1902, 1 ♂ (BMNH). COSTA RICA: Puerto Gofito, 4.vii.1965, 1 ♂ (Gordon B. Small, Jr. collection). MEXICO: CHI-APAS: Tierra Blanca, Mpio. La Trinitaria, 1500 m., 15.ix.1972, 1 ♂ (E. C. Welling M.) No Data, 2 ♀ (AMNH).

Evidently the Costa Rican record is a new, but not unexpected one. Hoffmann (1940: 672) lists *lapitha* from "*Tierra caliente de la costa del Pacifico de Chiapas*," no true specimens of that species are in the Hoffmann collection in the AMNH. All of the specimens in Hoffmann's material were *calderoni*, and one of these bore a determination label in Hoffmann's hand of "*Actinote lapitha* Staudinger." Since Hoffmann obviously confused *lapitha* with *calderoni*, we feel that Mr. Welling's specimen of the former is the first authentic record from Mexico.

A. lapitha was described from the Chiriqui region of Panama, but the type specimen is apparently no longer extant, perhaps having been



Figs. 19–22. *Actinote subhyalina* (Staudinger). 19–20, ♂, upper (19) and under (20) surfaces; PERU: Rio Cachiyacu, Iquitos (BMNH). 21–22, Lectotype ♀ (see designation in text), upper (21) and under (22) surfaces; PERU: Yurimaguas (ZMHU).

destroyed during World War II (H. J. Hannemann, *pers. comm.*). We have been unable to locate an authentic Chiriqui specimen in more recent collections; hence, we do not designate a Lectotype here.

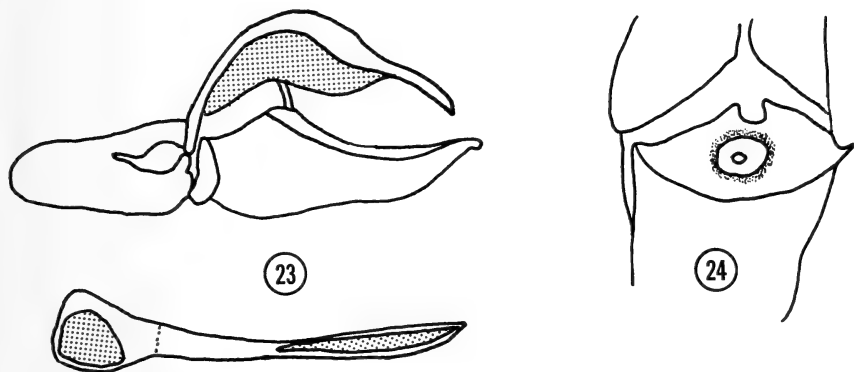
Actinote subhyalina (Staudinger), 1888

Figs. 19–24

Acraea subhyalina Staudinger, 1888: 81; pl. 32 (TL—Yurimaguas, Peru).

Description. Sexes similar: **Head, thorax and abdomen** above and below blackish-brown clothed with fuscous to buff scales. Palpi blackish-brown; legs brown and antennae dull reddish-brown. **Forewing above** buff, translucent and laved with fulvous toward base (darkest in ♂); apex and margin dull brown; veins darkened; transverse markings: a jagged blackish-brown one across cell about $\frac{3}{4}$ distance from base to end and a second one from costa across end cell to anal margin (not prominent below Cu_1 in ♂). **Hindwing above** buff, translucent, with darker veins; margin outlined in dull brown; interneural striping in anal region; prominent dark brown bar from costa to Cu_1 - Cu_2 and a dull brown mark across distal end of cell. **Under surface of wings** as above, but dull brown markings slightly overscaled with buff, hindwing distal band more diffuse and an additional dull brown stripe in hindwing cell $Sc+R_1$ - Rs . **Lengths of forewings** of all specimens examined ranged from 20 to 22 mm. **Genitalia** of ♂ and ♀ as illustrated.

Specimens examined. We have been able to examine only a single ♂ and six ♀ specimens. PERU: Rio Cachiyacu, Iquitos, [18]93, Stuart, 1♂ 3♀ (BMNH); Yurimaguas, 1♀ (ZMHU); No data, 2♀ (CM).



Figs. 23–24. *Actinote subhyalina* (Staudinger). 23, ♂ genitalia; PERU: Rio Cachiyacu, Iquitos; preparation M-3403 (Jacqueline Y. Miller). 24, ♀ genitalia of Lectotype; PERU: Yurimaguas; preparation M-3411 (Jacqueline Y. Miller).

Staudinger (1886: 81) described *A. subhyalina* from 12 ♀ specimens taken at Yurimaguas. Certainly the figured ♀ from Berlin was one of Staudinger's syntypes, and the two specimens from CM may have been, but in the case of the latter two specimens this cannot be ascertained with precision. One of the CM specimens bears the label "*Acraea subhyalina*/ from Dr. O. Staudinger/1885," a date that was three years before the description; the second specimen bears a number (Staudinger's?) only, "386." The specimen received from the ZMHU is definitely from the type locality, was in the Staudinger collection and has been labelled as "Origen" by Staudinger or someone subsequent to him. It is the logical candidate for designation as the Lectotype of the name, and we have so labelled it, affixing a red, partially printed, partially handwritten (*italics*) label to it: "Lectotype/ *Acraea subhyalina*/ Staudinger, 1888/ designated by Jacqueline Y. Miller/ & Lee D. Miller, 1977."

DISCUSSION

The impetus for this project was a series of seven specimens in the Allyn Museum collection from Mapastepec, Chiapas, Mexico. Examination of these specimens revealed that while they were closely related to *A. lapitha* (the name associated with them), they were abundantly distinct.

Letters for additional specimens brought two from the AMNH that were in agreement with the original description of *lapitha* (but without data) and five more of the odd one, four of which were from the

Hoffmann collection, taken by Dr. Escalante. A later trip to CM yielded one more specimen and the first clue to the identity of the Mexican material that we had. The additional label on the CM specimen stated that it was "*Actinote calderoni* Schaus," but at the time we were unable to find the original description or any reference to it, and we still assumed that the name might have been a manuscript name only. Re-checking the series and the type collection at the USNM yielded not only the type specimen of *calderoni*, but also finally the reference to the original description of this elusive name.

The confusion did not end there, though. The two true *lapitha* from the AMNH had a fulvous basal flush on the forewing, thus resembling *subhyalina*. This led us to wonder if the specimen figured by Staudinger (1888) was *subhyalina* or *lapitha*. Letters to the BMNH and the ZMHU brought additional specimens of Staudinger's insects and some very helpful information.

All three species are rare in collections, especially the males. Since we encountered such difficulty in making determinations in the *thalia* group, we present the following key to aid other workers to the species treated here.

1. Forewing above with dark transverse band at end cell from costa to near anal angle 2.
- 1'. Forewing with no such band; Mexico to El Salvador *calderoni* Schaus.
2. Hindwing above with prominent dark discal markings at end of cell; Peru *subhyalina* (Staudinger).
- 2'. Hindwing above without prominent marking at end cell; Mexico to Panama *lapitha* (Staudinger).

Essentially the key characters for the separation of the species in this complex are the dark bars across the cells of both wings. *A. subhyalina* shows these bars on the upper surfaces of both wings, *A. lapitha* has only the one on the forewing and *A. calderoni* has neither. Seemingly the orange flush at the base of the upper forewing should be diagnostic, but whereas it is prominent in most *subhyalina*, it also appears in some female *lapitha*, hence it is diagnostic of neither.

The male genitalia (Figs. 11, 17, 23) are similar, but subtly different, in all three species. The valvae are elongated and slightly curved dorsad in *calderoni*, whereas they are squarecut posteriad in both *lapitha* and *subhyalina*. The saccus of *subhyalina* is much more elongate than is that of either of the other two species.

Most of the differences between females of these species lie in the sterigmal region. The posterior margin of the lamella postvaginalis is U-shaped and narrow in *lapitha*, U-shaped and expanded in *subhyalina* and even more enlarged and W-shaped in *calderoni*. The entire opening

of the ostium bursae is darkly sclerotized in a narrow ring in *lapitha*, a somewhat broader darkly sclerotized ring in *subhyalina* but only darkly sclerotized in four separate areas around the opening in *calderoni*, but the area around the ostium itself is lightly sclerotized. The genital capsule is larger in *calderoni* than in the other species.

The tarsi, as is true of all members of the *thalia* group, are asymmetrical and comparable one with another.

Geographically *A. subhyalina* can be immediately separated from *lapitha* and *calderoni*, none of the three species being found in Colombia or Ecuador, as far as we know. It would not be surprising to see *subhyalina* from at least the latter country, and there might be sympatry between *subhyalina* and *lapitha* in Colombia. *A. lapitha*, as recorded here, has a much more extensive range than previously believed, and *calderoni* is not restricted to El Salvador. Either of these species, or both, may well be found in Honduras and Nicaragua. We hope that this paper will encourage others to try to fill in the distributional blanks for this interesting group.

ACKNOWLEDGMENTS

We are deeply indebted to the following for loan of material and for access to their collections (abbreviations) of *Actinote*: Dr. F. H. Rindge, American Museum of Natural History (AMNH); Mr. H. K. Clench, Carnegie Museum of Natural History (CM); Mr. W. D. Field, National Museum of Natural History (USNM); Mr. P. R. Ackery, British Museum (Natural History) (BMNH); Dr. H. J. Hannemann, Zoologische Museum der Humboldt Universität (ZMHU); Dr. T. Escalante and Messrs. R. de la Maza R. and J. de la Maza E., Mexico, D. F., Mexico; Mr. E. C. Welling M., Merida, Yucatan, Mexico and Mr. G. B. Small, Jr., Balboa, Canal Zone. The Allyn Museum of Entomology is abbreviated AME in part of the paper.

Mr. Field and Dr. J. F. G. Clarke of the USNM were instrumental in obtaining a copy of the Schaus paper for us. We also thank Mr. S. R. Steinhauser for pointing out the Franz and Schröder paper to us and to Mr. H. W. Dybas of the Field Museum for obtaining a copy of it for our use.

Special thanks are due Mr. A. C. Allyn of this institution for taking the photographs contained herein and for reading the manuscript.

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PAPILIO ARISTODEMUS (PAPILIONIDAE) IN THE BAHAMAS

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ABSTRACT. Two subspecies of *Papilio aristodemus* Esper, both new, are described from the Bahamas: *driophilus* (TL: Cutlass Bay, near Dolphin Head, Cat Island), known from Cat, South Andros, and North Andros islands; and *bjorndalae* (TL: Man of War Bay, Great Inagua Island), known only from Inagua and strikingly different from any known subspecies, though apparently derived from *driophilus*.

Papilio aristodemus is an Antillean swallowtail with a strong tendency to vary geographically. Nominate *aristodemus* Esper 1794 occurs on Hispaniola; the subspecies *temenes* Godart 1819 is found on Cuba and on Little Cayman in the Cayman Islands (Carpenter & Lewis 1943); subspecies *ponceanus* Schaus 1911 is known only from southeastern Florida, particularly Key Largo. An old record of the species for Puerto Rico (*cf.* Comstock 1944: 535), subspecies unknown, is not substantiated by more recent captures.

This species recently has been discovered in the Bahamas (Clench, 1977). I first found it on South Andros Island in early June 1974. A year later, in early June 1975, I took it also at the southern end of Cat Island, and in 1976 I collected a specimen on North Andros. The populations on these islands are not absolutely identical, but they are close enough to be referred to the same subspecies, described below as *driophilus*.

Miss Karen Bjorndal, a graduate student at the University of Florida, Gainesville, spent over a year on Great Inagua Island, from April 1975 to August 1976, studying the energy budget and nutritional ecology of the Green Turtle, *Chelonia midas*. While there she also made a collection of butterflies, which she has generously donated to Carnegie Museum of Natural History. In her collection are two specimens of a striking new subspecies of *aristodemus*, in several ways the most distinct of all. It is a pleasure to name it in honor of Miss Bjorndal.

***Papilio aristodemus driophilus*, new subspecies**

Papilio aristodemus ponceanus: Clench 1977:190.

Description. Much closer to *ponceanus* (Florida) than to either *a. aristodemus* (Hispaniola) or *temenes* (Cuba). This is shown particularly by its sharing with *ponceanus* such traits as the thin median yellow-ocher band, and the complete, only slightly curved, subterminal row of yellow-ocher lunules, both on the forewing above. From *ponceanus*, however, it differs in these ways:

- (1) On the hindwing upperside the subterminal yellow, orange, or red-orange spot

in *Cu₂-2A* is completely separated by a black bar from the terminal yellow or orange distad. In *ponceanus* these two pale areas are connected by a narrow isthmus along *Cu₂*.

(2) On the forewing above, the cell is rather densely and evenly sprinkled with pale (greenish) scales. In *ponceanus* the sprinkling is extremely sparse and tends to be limited to the basal and costal parts of the cell.

(3) The projections of the hindwing termen at the vein-ends (including the tail) are longer than they usually are in *ponceanus* (but the latter is inclined to be variable in this respect).

(4) On the forewing above, the segment of the median band in *M₁-M₂* is broadly in contact with the next posterior segment, in *M₂-M₃*. In *ponceanus* the *M₁-M₂* segment is smaller, and posteriorly separated from the next one by a fuscous gap or (rarely) touches the next segment at a point only: the two segments are never in broad contact.

(5) On the hindwing upperside the median pale band is somewhat broader than in *ponceanus*. In *driophilus* the segment in the cell is consistently wider than the fuscous in the cell just distad; in *ponceanus* the pale band is here subequal to the fuscous in width, or it is somewhat narrower.

Length of forewing. Male, one only, 47.0 mm; female, 48.0–50.0 mm, mean (of 4), 49.1 mm. Measurements are of the type series only.

Types. HOLOTYPE, ♀, Cutlass Bay, near Dolphin Head, southern Cat Island, Bahamas, 6.vi.1975, leg. H. Clench, sta. 259 b; C. M. Acc. 27783. PARATYPES, 1 ♂ 3 ♀, as follows: 2 ♀, same data as holotype; 1 ♂ 1 ♀, the same except 4.vi, sta. 257 b. Holotype and paratypes, C. M. Ent. type series no. 680.

Remarks. In addition to the type series I have examined 4 ♂ 2 ♀ from South Andros Island, Bahamas: ca. 2 mi S Driggs Hill, 2–8.vi.1974, leg. H. Clench. The forewing length of this series is as follows: males, 43.5–49.0 mm, mean (of 4), 45.0 mm; females, 47.5–51.0 mm, mean (of 2), 49.2 mm. These specimens agree closely enough with the Cat Island series, notably in all points mentioned in the above description, that I believe them correctly referred to the subspecies *driophilus*. The agreement, however, is not perfect and the two island samples show a few, mostly statistical, differences:

(a) On the hindwing above, the subternal pale spot (as in (1) above) is dark orange, with little or no pale edging, in all the Cat Island specimens; it is light orange, more or less heavily edged laterally with yellow, in all but 1 ♂ from South Andros (in which it is dark orange). (In *ponceanus*: dark orange with slight lateral yellow.)

(b) On the hindwing above, a small rusty spot in the base of cell *M₃-Cu₁* is present in 1 ♂ 1 ♀ (40%) of the Cat Island series, but is totally absent from the South Andros series. (In *ponceanus*: 56%).

(c) The discal cell on the forewing underside is filled with smooth, pale yellow-ocher in all Cat Island specimens; in all South Andros specimens the cell has peripheral fuscous and faint distal longitudinal fuscous streaks. (In *ponceanus*: as on South Andros, but the fuscous is even heavier.)

(d) On the forewing underside, the subapical transverse fuscous bar from costa (just distad of, and parallel to, the conspicuous pale bar on the forewing upperside) extends inward to cross cell *R₅-M₁* in 1 ♂ (17%) from South Andros, in 4 ♀ (80%) from Cat Island. In the remaining individuals it does not reach that interspace (In *ponceanus*: 22%).

On South Andros *driophilus* flew in dense scrub, usually 1–2 m above the ground, only briefly and occasionally pausing to feed at the flowers of shrubs in that height range. The butterflies were mostly in the scrub itself and they entered roadways or other open areas only to cross from

one part of the scrub to another. These habits they shared fully with *P. andraemon bonhotei* Sharpe 1900, which flew with *driophilus*, and the two were virtually indistinguishable on the wing. On Cat Island the habits of *driophilus* were similar except that individuals were seen more often in open areas, especially at the flowers of ornamental vines and shrubs around the hotel where I stayed.

On 28 September 1976 I took a single male *driophilus* just north of Nicolls Town, North Andros, a new record for that island. I saw no others and am at a loss to explain the late capture date. The butterfly is quite fresh and was found flying in a somewhat overgrown old field. It, too, is referable to the new subspecies, although differing in a few respects (e.g., the median pale band on the hindwing above is thicker than in any other *driophilus* seen except one of the female paratypes from Cat Island; and its distal edge is straight [as in *bjorndalae*], not convex near R_s and M_1). With regard to traits (a) through (d) above: (a) the subternal pale spot is dark orange with slight lateral yellow (as in *ponceanus*); (b) it has no rusty spot in M_3 - Cu_1 ; (c) on the forewing below it agrees with South Andros specimens in the discal cell coloration; (d) also on the forewing below, the subapical fuscous bar extends inward only to R_5 .

***Papilio aristodemus bjorndalae*, new subspecies**

Description. Differs in two major traits from all previously known subspecies of *aristodemus*: (1) a large patch of rusty red is present on the hindwing upperside between M_2 and the inner margin, and between the cell-end and the diffuse, faint band of sprinkled blue scaling that basally edges the subterminal row of pale spots; and (2) on the hindwing, both above and below, the subterminal pale spots posterior to M_2 are distally displaced and reduced in size, so that the row is essentially parallel to the termen throughout and the component spots are of similar thickness and more quadrate (less lunular). The latter trait is particularly conspicuous on the underside. The rusty red patch varies in the two specimens at hand, but I cannot tell whether the variation is sexual or individual. In the female the patch is large, the component spots contiguous, and there is even a minute extra dot of the same color in M_1 - M_2 ; in the male the component spot in Cu_1 - Cu_2 is wanting, and those in M_2 - M_3 - Cu_1 are thin and short, separated by fuscous along the veins.

The median pale band of the forewing upperside is thin, as in subspecies *ponceanus*, *driophilus*, and *aristodemus*, and slightly or not at all broken at M_2 , as in *driophilus*; on the forewing upperside the subterminal row of pale spots is lightly curved (as in all subspecies except nominate *aristodemus*, in which it is strongly curved, almost angulate, near Cu_1), and continues strongly costad to R_1 , as in *ponceanus* (in *a. aristodemus* it stops at M_2 ; in *temenes* at about M_1 ; in *driophilus* at R_5 or R_4 , the segment in R_4 - R_5 being often weak or wanting). On the hindwing upperside, in Cu_2 -inner margin, the subterminal pale bar is connected to the pale terminal area by a narrow isthmus along Cu_2 , as in *ponceanus* (in all other subspecies the two pale areas are usually completely separated by intervening fuscous). The median pale band on the hindwing upperside is thin, about as in *ponceanus* or even thinner, and about half as thick as that in *driophilus*, and its distal edge is straight, not convex near R_s , as it is in *ponceanus* and *driophilus*. This median band

posteriorly curves distad at the inner margin and runs along the margin almost to the blue bar, as in *driophilus* (in the others it intersects the inner margin at a high—often right—angle and does not run distad). Basad of the subterminal pale spots is a band of sprinkled blue scales, strongest in Cu_2-2A but extending, weaker, costad to M_1 or Rs , essentially as in *driophilus* and *ponceanus* (in nominate *aristodemus* it is absent except for the segment in Cu_2-2A , and in *temenes* it is usually so). Both specimens are smaller than any other *aristodemus* I have seen.

Length of forewing. Male, 40.0 mm; female, 44.0 mm.

Types. HOLOTYPE, ♀, Man of War Bay, Great Inagua Island, Bahamas, 4.x.1975, leg. Karen Bjorndal. C. M. Acc. 29104. PARATYPE, ♂, Calf Pond, northwestern Great Inagua, 18.v.1976, leg. Karen Bjorndal. C. M. Acc. 29104. Holotype and paratype, C. M. Ent. type series no. 690.

Remarks. This subspecies apparently was derived from *driophilus* of the central Bahamas, although it has departed from it to an unusual and striking degree. The large rusty red patch on the hindwing above gives it a distinctive appearance, but the patch is foreshadowed by the small, obscure, rusty red spot that appears in M_3-Cu_1 in some *driophilus* and *ponceanus* (see character (b) in the *Remarks* under *driophilus* above).

Miss Bjorndal comments (*in litt.*): "From September to December [1975] and from May to August [1976] swallowtails were flying on Inagua. I was unable to distinguish which species [*aristodemus* or *andraemon*]. They were commonly seen in open scrub, dense scrub, coppice, coastal areas and [in the residential area of] Matthew Town."

In April 1977 on Little Inagua Island I repeatedly saw, but was unable to capture, a swallowtail in the short, narrow strip of low forest on the western coast, about a mile south of Northwest Point. Like Miss Bjorndal, I was unable to tell which of the two species it might have been.

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THE NAMES OF CERTAIN HOLARCTIC HAIRSTREAK GENERA (LYCAENIDAE)

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ABSTRACT. The palearctic genus *Strymonidia* Tutt 1908 and the nearctic genus *Euristrymon* Clench 1961, both in current use, are both synonymized to *Fixsenia* Tutt 1907, on the basis of male genital structure. The currently used palearctic genus *Nordmannia* Tutt 1907, and many other generic names not in general use, must be synonymized to *Satyrium* Scudder 1876, on similar structural evidence. Both *Fixsenia* and *Satyrium* are shown to be holarctic, and both are unusually variable in external facies. All species known to belong to both genera are listed.

The correct generic names to be applied to some of the palearctic hairstreaks has long been a problem. The species concerned are those listed by Higgins & Riley (1970: 235-238) and Higgins (1975: 109-112) for Europe under the genera *Nordmannia* and *Strymonidia*, together with numerous related species in the central and eastern Palearctic. The usage of Higgins & Riley, and Higgins, is representative of that current in the Palearctic literature. Study indicates, however, that neither of these generic names is tenable, and that assignment of the species (i.e., which species are congeneric with which) must be modified.

Malicky (1969) has shown that the long unused generic name *Fixsenia* Tutt must be revived for the widespread species *pruni* Linnaeus in addition to the (Asiatic) type species, *herzi* Fixsen. Some time ago I pointed out (Clench 1961: 212) that *pruni* was congeneric with certain North American hairstreaks to which I gave the new generic name *Euristrymon*. In consequence of Malicky's discovery, *Euristrymon* must therefore fall to *Fixsenia*.

Malicky also concluded that other Old World hairstreaks (he specifically cites *spini*, *ilicis*, *w-album*, and *acaciae*) are congeneric among themselves, and collectively differ from *Fixsenia* in the presence of a serrated ventral keel at the distal end of the penis in the male genitalia, as well as in certain larval and pupal characters. Malicky assigned all these species to the genus *Strymonidia* Tutt, a name which has long been in general use for many of them. The name *Strymonidia*, however, has as its generic type another little known species from Asia, *thalia* Leech, which Malicky was not able to study. I have seen no *thalia* either, but from published illustrations it seemed quite similar to *herzi*, the type of *Fixsenia*, and I was curious about its genitalic structure. In correspondence with Dr. Malicky I asked him about it. He was able to borrow a specimen and sent me a drawing of the genitalic

preparation he made. This showed clearly that *thalia* is indeed congeneric with *herzi*. Therefore the generic name *Strymonidia* is also a synonym of *Fixsenia* and cannot be applied to the species Malicky cites.

The species Malicky included in *Strymonidia*, and additional Old World species as well, are themselves congeneric with a large number of Nearctic species now united in the genus *Satyrrium* Scudder. This name, *Satyrrium*, has priority over any other and must therefore be applied to these palearctic species.

The discovery that the numerous species of *Satyrrium* in both Old and New Worlds are all congeneric has created a large generic synonymy, particularly involving the Palearctic species. The apparent reason is that despite their close structural similarity they have diversified to a considerable degree in appearance. A number of species, among them the type of the genus, combine the un-hairstreak attributes of inconspicuous or absent scent pad, absence of tails and tornal lobe, and essentially spotted patterns. They much resemble blues, and many were originally so described. Bethune-Baker (1892), in fact, made a special point of demonstrating that several of them were actually hairstreaks instead of blues.

The external structural diversity of *Satyrrium* and *Fixsenia*, in male scent pad, in wing shape, in tails, and in pattern, finds a remarkable parallel in the New World hairstreak genus *Strymon* Hübner 1818 (i.e., as delimited in Clench 1961: 215ff). In *Strymon* an even more striking genitalic homogeneity is associated with similar variation in external structures. Apparently in both these genera extensive adaptive radiation has occurred, although the environmental significance of most of the affected external traits remains largely obscure.

The male genitalia of the European species of both these genera are well figured by Higgins (1975).

The formal synonymy and nomenclatorial data for both *Fixsenia* and *Satyrrium*, together with their characters and known included species, are as follows:

Fixsenia Tutt

- Fixsenia* Tutt 1907, Nat. Hist. British Butts. 2: 142, type species by original designation, *Thecla herzi* Fixsen 1887; Hemming 1967: 193; Malicky 1969: 38, 61.
 = *Leechia* Tutt 1907, l.c., type species by original designation, *Thecla thalia* Leech 1893; Hemming 1967: 249. Junior homonym of *Leechia* South 1901. See *Strymonidia*.
 = *Strymonidia* Tutt 1908, op. cit.: 483, replacement name for *Leechia* Tutt 1907, q.v., with the same type species; Hemming 1967: 419. New subjective synonym.
 = *Euristrymon* Clench 1961: 212, type species by original designation, *Papilio favonius* J. E. Smith 1797; Cowan 1970: 10; dos Passos 1970, J. Lepid. Soc. 24: 33. New subjective synonym.
 = *Thecla*, *Nordmannia*, etc., of authors, in part.

The **generic characters** of *Fixsenia* are: hindwings usually tailed, tornal lobe usually present, if slight, but no tornal cleft. **Male genitalia:** uncus lobes low and transverse, the lateral border short; vinculum with dorsal part wide, but without posterior shoulder process, abruptly narrowing to the strap-like ventral part; anterior border of vinculum without corematal processes; saccus present but short, rarely if ever longer than its width at middle; valvae contiguous to more or less their middle, then divergent, the mesial edges not dentate, and with no terminal spine; penis apically upcurved and flared, with two terminal cornuti of about equal diameter, but with no terminal ventral keel.

In the Palearctic the last character, the absence of a ventral penial keel, is sufficient to separate *Fixsenia* from *Satyrrium*, the only other genus with which it may be confused; but the remaining characters are necessary to discriminate it from other New World Strymonine genera. The known members are:

Palearctic species: *herzi* Fixsen 1887; *thalia* Leech 1893; *pruni* Linnaeus 1758.

Nearctic species: *favonius* J. E. Smith 1797; *ontario* Edwards 1868; *polingi* Barnes & Benjamin 1926.

Satyrrium Scudder

- = *Argus* Gerhard 1850, Versuch. Mon. europ. Schmett. (1):4, type species by monotypy, *Lycaena ledereri* Boisduval 1848; Hemming 1967: 56. Junior homonym of *Argus* Bohadsch 1761.
- Satyrrium* Scudder 1876, Bull. Buffalo Soc. Nat. Sci. 3: 106, type species by original designation, *Lycaena fuliginosa* Edwards 1861; Comstock & Huntington 1958, J. New York Ent. Soc. 66: 116; Ziegler 1960, J. Lepid. Soc. 14: 20; Hemming 1967: 403; dos Passos 1970, *op. cit.*: 28.
- = *Callipsyche* Scudder 1876, *l.c.*, type species by original designation, *Thecla behrii* Edwards 1870; Comstock & Huntington 1958, *op. cit.*: 105; Hemming 1967: 91.
- = *Neolycaena* de Niceville 1890, Butts. India, Burmah and Ceylon 3: 15, 64, type species by original designation, *Lycaena sinensis* Alphéraky 1881; Hemming 1967: 308.
- = *Edwardsia* Tutt 1907, *l.c.*, type species by original designation, *Papilio w-album* Knoch 1782; Hemming 1967: 156. Junior homonym of *Edwardsia* Costa 1838. See *Chattendenia*.
- = *Felderia* Tutt 1907, *l.c.*, type species by original designation, *Thecla w-album* Knoch 1782; Hemming 1967: 156. Junior homonym of *Edwardsia* Costa 1838. See *Chattendenia*.
- = *Felderia* Tutt 1907, *l.c.*, type species by original designation, *Thecla w-album* Knoch var. *eximia* Fixsen 1887; Hemming 1967: 193. Junior homonym of *Felderia* Walsingham 1887. See *Thecliolia*.
- = *Klugia* Tutt 1907, *l.c.*, type species by original designation, *Papilio spini* [Denis & Schiffermüller] 1775; Hemming 1967: 242. Junior homonym of *Klugia* Robineau-Desvoidy 1863. See *Tuttiola*.
- = *Kollaria* Tutt 1907, *l.c.*, type species by original designation, *Thecla sassanides* Kollar [1849]; Hemming 1967: 242. Junior homonym of *Kollaria* Pictet 1841. See *Superflua*.
- = *Erschoffia* Tutt 1907, *l.c.*, type species by original designation, *Thecla lunulata* Erschoff 1874; Hemming 1967: 169. Junior homonym of *Erschoffia* Swinhoe 1900. See *Pseudothecla*.
- = *Bakeria* Tutt 1907, *l.c.*, type species by original designation, *Lycaena ledereri* Boisduval 1848; Hemming 1967: 72. Junior homonym of *Bakeria* Kieffer 1905, but never replaced.

- = *Nordmannia* Tutt 1907, *l.c.*, type species by original designation, *Lycaena myrtale* Klug 1834; Hemming 1967: 315.
- = *Chattendenia* Tutt 1908, *op. cit.*: 483; Hemming 1967: 109. Replacement name for *Edwardsia* Tutt 1907, *q.v.*, with the same type species.
- = *Thecliolia* Strand 1910, *Entomol. Rundsch.* 27: 162; Hemming 1967: 439. Replacement name for *Felderia* Tutt 1907, *q.v.*, with the same type species.
- = *Tuttiola* Strand 1910, *l.c.*; Hemming 1967: 451. Replacement name for *Klugia* Tutt 1907, *q.v.*, with the same type species.
- = *Superflua* Strand 1910, *l.c.*; Hemming 1967: 420. Replacement name for *Kollaria* Tutt 1907, *q.v.*, with the same type species.
- = *Pseudothecla* Strand 1910, *l.c.*; Hemming 1967: 386. Replacement name for *Erschoffia* Tutt 1907, *q.v.*, with the same type species.
- = *Thecliola* Waterhouse 1912, *Index Zool.* 2: 299; Hemming 1967: 439. Incorrect Subsequent Spelling of *Thecliolia*, *q.v.*
- = *Necovatia* Verity 1951, *Rev. franç. Lépid., Suppl.*: 183, type species by original designation, *Papilio acaciae* Fabricius 1787 [proposed as a subgenus of *Strymonidia* Tutt 1908, *vide supra*]. Note: This generic name was overlooked by Hemming (1967), Cowan (1968, 1970), and the *Zoological Record*. I thank Lt. Col. J. N. Eliot for calling it to my attention.
- = *Thecla*, *Strymon*, *Strymonidia*, etc., of authors (in part).

I have examined the male genitalia of the following species and find them all congeneric:

fuliginosum, type species of *Satyrium*
behrii, type species of *Callipsyche*
w-album, type species of *Edwardsia*, *Chattendenia*
spini, type species of *Klugia*, *Tuttiola*
sassanides, type species of *Kollaria*, *Superflua*
lunulatum, type species of *Erschoffia*, *Pseudothecla*
ledereri, type species of *Bakeria*
myrtale, type species of *Nordmannia*
acaciae, type species of *Necovatia*

I have not seen the species *sinensis* (type species of *Neolycaena*), but *pretiosum* Staudinger is extremely closely related, perhaps conspecific, and its genitalia, along with those of some other *Satyrium*, were figured by Bethune Baker (1892). His figures show that *pretiosum*, and hence most likely *sinensis*, is a *Satyrium*. I have not seen *eximium* Fixsen (type species of *Felderia*, *Thecliolia*), but from illustrations it seems to be a close relative of *w-album* and I conclude, therefore, that it is probably congeneric.

The **generic characters** of *Satyrium* are: **male genitalia**: distal end of penis with ventral serrated keel; penis with two terminal cornuti, one of which is usually dentate; distally divergent valvae; tips of valvae without a mesial hair-like fringe.

In the Palearctic the presence of a serrated penial keel will discriminate it from *Fixsenia*, or any other Strymonine. In the New World, however, several other genera share this keel, from which the additional characters will separate it. The known species belonging to *Satyrium* are as follows. I include only those whose genitalia I have examined either directly or in published illustrations, except for the species fol-

lowed by "(?)," which are included provisionally, on the basis of external facies alone.

Palaearctic species: *eximium* Fixsen 1887 (?); *w-album* Knoch 1782; *spini* [Denis & Schiffermüller] 1775; *latior* Fixsen 1887; *sassanides* Kollar 1849; *lunulatum* Erschoff 1874; *pretiosum* Staudinger 1886; *sinensis* Alpheraky 1881 (?); *ledereri* Boisduval 1848; *myrtale* Klug 1834; *tengstroemii* Erschoff 1874; *ilicis* Esper 1779; *acaciae* Fabricius 1787.

Nearctic species: *fuliginosum* Edwards 1861; *behrii* Edwards 1870; *auretorum* Boisduval 1852; *saepium* Boisduval 1852; *tetra* Edwards 1870 (= *adenostomatis* Hy. Edwards 1877); *liparops* Le Conte 1833; *kingi* Klots & Clench 1952; *calanus* Hübner 1809; *caryaevorum* McDunnough 1942; *edwardsii* Scudder 1870; *sylvinum* Boisduval 1852; *californicum* Edwards 1862; *acadicum* Edwards 1862.

It is worth noting that at one time it was believed (e.g., Riley 1958: 285) that *myrtale* was congeneric with *Erora* Scudder 1872. The latter genus, however, is representative of a wholly New World, primarily tropical, group with no palaearctic members at all. This group differs considerably from *Satyrium*, not only in the absence of a serrated penial keel, but also in the high lateral margins of the uncus lobes, the single, always interior, cornutus, and in addition a terminal penial tooth that is either external and part of the shaft or else internal, on the vesica, and eversible. The vesica, moreover, is usually scobinate.

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OVER-WINTERING BEHAVIOR IN *EUPHYDRYAS PHAETON* (NYMPHALIDAE)

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ABSTRACT. The behavior of the pre-diapause larvae of *Euphydryas phaeton* (Nymphalidae) associated with over-wintering is described. Observations are based on studies of five wild populations in central Massachusetts over a three-year period, as well as on larvae reared in the laboratory. The functional significance of this larval behavior is discussed.

Most Lepidoptera over-winter as either an egg or pupa; some nymphalid butterflies (e.g. the Mourning Cloak, *Nymphalis antiopa* L., and Compton's Tortoiseshell, *N. vau-album* Boisduval and Leconte), and certain groups of moths [e.g. the Lithophanini (Schweitzer, 1977)] overwinter as adults. In only a relatively few cases do Lepidoptera spend the winter in the larval stage. The Viceroy, *Limenitis archippus* Cramer (Nymphalidae) for example, is multivoltine and may enter a facultative diapause in the third instar during late summer and fall (Hong and Platt, 1975). Unusually, however, the Baltimore Checkerspot, *Euphydryas phaeton* Drury (Nymphalidae), and other members of the genus *Euphydryas*, are univoltine and exhibit an obligatory diapause in the fourth instar.

Although some descriptive work has been done on the development of the early, pre-diapause instars of *E. phaeton*, little has been reported of the actual behavior of the larvae during over-wintering. Observations on several wild colonies of *E. phaeton* and on larvae reared in the laboratory have revealed some interesting behavioral aspects of the over-wintering process in this species.

METHODS

Observations were made on five colonies of *E. phaeton* in Hampshire, Franklin, and Hamden Counties in central Massachusetts from 1974-1977. The site of each colony was wet and marshy, typical habitat for *E. phaeton* and its primary foodplant, Turtlehead (*Chelone glabra* L., Scrophulariaceae). The five sites differed in elevation, area, amount of Turtlehead present, and size of the *E. phaeton* population; but these differences were not factors in the present study.

At each of the colonies, I determined the absolute numbers of egg masses, and (later) larval webs. At the three largest colonies, heights of the pre-hibernation webs above the ground were measured. All

colonies were usually observed at least once a week. In addition I reared larvae from eggs in the laboratory at 22–25°C under continuous light. Developmental times for each instar, dates of larvae entering the pre-hibernation web and ceasing feeding, and time to the third molt were recorded for these larvae.

OBSERVATIONS

Euphydryas phaeton females usually oviposit two to three large masses of from 100–600 eggs each (Scudder, 1889; Bowers, pers. obs.) from late June through July in Massachusetts. The eggs hatch in about 20 days. When the larvae hatch they may construct a small web on the leaf next to the egg shell but move to the growing tip of the plant within 24 hours and begin web construction and feeding. This feeding web is extended down the length of a stalk of Turtlehead as the larvae devour the leaves. The larvae are gregarious and develop to the end of the third instar in approximately three weeks.

About mid-August in central Massachusetts, the larvae stop feeding, and thicken and compact a section of the web (this date may vary widely, depending on the hatch date of a particular cohort of larvae, elevation, and current climatic conditions). Upon entering this “pre-hibernation web” larvae become quiescent and molt to the fourth instar in about five days (from 3–7 days in the laboratory) (Edwards, 1875; Scudder, 1889; Bowers, pers. obs.). Edwards (1875) reported that larvae enter this web about 15 July in West Virginia, but at higher elevations in Massachusetts this web entrance can occur as late as the second week in September.

Previous authors (e.g. Scudder, 1889; Clark, 1927) have referred to this strengthened and compacted web as the “hibernating web.” However, larvae do not spend the winter in this web at all, but leave it and move into the litter; this web is thus better referred to as the “pre-hibernation web,” which is the term used throughout this paper. This designation also serves to differentiate it from the feeding web which encloses plant parts on which the larvae are feeding.

The pre-hibernation web may be constructed at the base of the Turtlehead stalk on which the larvae have been feeding, but is sometimes found a short distance away. This web, as well as the feeding web constructed throughout the development of the pre-hibernation larvae, includes the stalk and leaves of Turtlehead as well as adjacent plants such as ferns, grasses and herbs (Figs. 1–3). The pre-hibernation webs are always constructed above ground level; most are found at a height of more than 50 cm. The mean height for 43 pre-hibernation



webs measured in the summer of 1976 was 73 cm (range: 30–127 cm; standard deviation: ± 25.50). I have never observed a pre-hibernation web directly on the ground.

Once the larvae enter the pre-hibernation web they do not feed at all. There may be some movement and occasionally a larva or two will leave and wander over the web surface. If the larvae are disturbed by movement of the web, they will move around a bit, but are usually inactive. An exception to this occurs when the web is damaged by storms or predators. In order to observe larval reactions to such damage, I broke open several webs. When the web is broken, the larvae begin moving around almost immediately and one or two larvae begin to crawl out of the web and over the surface. Other larvae soon follow. Within a day or two the web has been repaired and the larvae return to their inactive state. Thus, although the larvae are quiescent and not feeding, they can still react to stimuli such as disruption of the web.

The larvae do not spend the winter inside this web as has been suggested by previous authors (e.g. Edwards, 1875; Scudder, 1889; Clark, 1927). Rather, about the end of October, the larvae move out of the web *en masse* to the base of a plant on which the pre-hibernation web was constructed. Here they form a large contiguous aggregation among the dead grass and litter on the ground. This movement occurred during the weeks 27 October–4 November 1975, 22 October–29 October 1976, and 20 October–27 October 1977. While in this aggregation, individual larvae are active on warm days, moving from the primary mass as far as 25 cm. On cool, cloudy days or early in the morning, the larvae are usually found in a tight group, but individuals will quickly move around and out of the mass when disturbed. After approximately a week (from two days to two weeks; different for each aggregation of larvae), groups of about 10 to 100 individuals from this large mass move distances of 5–100 cm away and roll up leaves and bits of debris and fasten them with silk. It is here that they spend the winter. From 1974 to 1977 over 100 pre-hibernation webs were examined and in all webs the larvae moved into the litter. All the larvae remain near the pre-hibernation web and thus close to the Turtlehead stalk on which

←

Figs. 1–3. Development of the feeding web of *E. phaeton* on *C. glabra*: 1, beginning web formation at top of plant; 2, further development of web with more leaves enclosed; 3, extension of web to encompass several stalks of *C. glabra* and adjacent plants.

they originally fed. Because Turtlehead is perennial this behavior ensures an adequate food supply for larvae emerging the following spring.

On warm, sunny days during the winter, larvae may become active, and groups may shift position by a few cm, rolling up new leaves in which to spend the remainder of the winter.

When the larvae are dug up from under the snow in January and brought to temperatures of 20–25°C, they quickly become active and crawl around the container in which they are confined. Usually they will not feed at this time. Clark (1927) brought hibernating larvae indoors in February and tried feeding them forced shoots of *Lonicera japonica* Thunb. (Caprifoliaceae), an alternate foodplant for this species (Clark, 1927; Scudder, 1889). After wandering around for a week, they began to feed, but all eventually died before reaching pupation. If larvae are brought indoors in this manner, allowed to be active and then returned to outside conditions, they resume their resting state with no apparent ill effects, emerging from diapause in the normal manner in the spring.

I attempted to break diapause in *E. phaeton* by subjecting several egg masses and their emerging larvae to 24 hours of light throughout development and hibernation. Although little is known about breaking diapause in univoltine insects, Beck (1968) suggests this method. These lab-reared larvae formed a pre-hibernation web in the same way as larvae in the field, yet were occasionally active. The larvae were given fresh food when plants seemed wilted or were consumed, and they fed occasionally through the end of October, with approximately 40% mortality. Between 25 October to 1 November there was a fourth molt (which does not occur in natural populations) that was synchronized within any single group of larvae but not among the groups. After this time, most of the larvae were inactive, and by mid-January all the larvae had died. Although attempts to break diapause in other insects with an obligatory diapause have been successful (e.g. Beck, 1968), this attempt was not. None of the larvae survived and none exceeded the size attained by hibernating larvae in the field. Thus diapause in this univoltine insect is truly obligatory and probably under genetic rather than photoperiodic control; the latter is probably the case in most multivoltine species (Beck, 1968; Hong and Platt, 1975).

DISCUSSION

Early authors (e.g. Scudder (1889) and Edwards (1884)) believed that the larvae of *E. phaeton* spent the winter in the pre-hibernation web (which they called the "hibernation web"). Observation of these

webs throughout the fall in Massachusetts shows that it would not be feasible for larvae to remain in the web: although the pre-hibernation web has many more layers of silk and is smaller and more compact than the feeding web, wind and rain begin to damage it by the end of October. Before winter has advanced very far there is little left of the web, and the larvae cannot repair the web during the winter.

One of the harshest winter microclimates is just above the snow level where most of the pre-hibernation webs are found. Air temperature fluctuations here are much more dramatic than those at the soil surface (MacKinney, 1929; Mail, 1932) where larvae aggregate. Vegetation and litter reduce these temperature fluctuations, and snow provides further insulation (MacKinney, 1929; Mail, 1932). In Massachusetts there is snow cover for most of the winter and thus the larvae are quite well protected. Wind is also an important agent above the snow or ground level, but would have little impact on the larvae under snow or litter cover. Thus, regardless of snow cover, by moving out of the pre-hibernation web into the litter, larvae escape extreme temperature fluctuations and the desiccating effects of wind characteristic of winter conditions.

The question, then, is why should larvae construct a pre-hibernation web at all; why not move into the litter in August when feeding stops? Perhaps the groups of hibernating larvae would be easy prey for ground predators such as spiders and beetles which are abundant at the end of the summer. By the end of October, however, most of these predators are absent or inactive and the larvae could safely move into the litter.

In summary, pre-hibernation larvae of *E. phaeton* exhibit three major behavioral sequences: first, construction of the feeding web during the first three instars; second, abandonment of this web and construction of a small, compact pre-hibernation web in which the larvae remain quiescent; third, departure from this web and movement of smaller groups into the litter where they form an over-wintering site by rolling up leaves and bits of debris and fastening them with silk. The last two sequences require appreciable expenditures of energy (for movement and silk-making) while no food is being eaten. This expenditure suggests that these behaviors are necessary to ensure larval survival over the fall and winter.

ACKNOWLEDGMENTS

I am very grateful to Dr. Theodore D. Sargent for his encouragement and editorial comments. This research was supported in part by a Sigma Xi Grant-in-Aid of Research.

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INTER-SPECIFIC HYBRIDIZATION INVOLVING *LIMENITIS* *ARCHIPPUS* AND ITS CONGENERIC SPECIES (NYMPHALIDAE)

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ABSTRACT. The occurrence of 43 natural hybrids involving *Limenitis archippus* and its congeneric species (*L. arthemis-astyanax*, *L. lorquini*, and *L. weidemeyerii*) is reviewed. Nine of these hybrid records are reported for the first time. Data based on laboratory crosses are given in order to document the purported wild hybrid specimens. Reasons underlying the observed natural hybridization are suggested and their evolutionary implications are discussed.

Species of the North American genus *Limenitis* readily undergo inter-specific hybridization both in nature and in the laboratory (Edwards, 1882; Scudder, 1889; Field, 1904, 1914; Newcomb, 1907; Gunder, 1934; Remington, 1958, 1968; Platt, 1975). The occurrence of 22 natural hybrids and the laboratory documentation of them in crosses involving either 1) *L. arthemis arthemis* Drury or 2) *L. arthemis astyanax* Fabricius \times *L. archippus* Cramer have been reviewed and discussed by Monroe (1953); Grey (1968); Shapiro and Biggs (1968); Platt and Greenfield (1971), and Greenfield and Platt (1974). Since then, Johnson (1974) and Arbogast (1976) have reported two other wild-collected *L. arthemis astyanax* \times *L. archippus* hybrid specimens. Likewise, the natural occurrence of four *L. lorquini* Boisduval \times *L. archippus* hybrids (Gage, 1970; Perkins and Gage, 1970) and five *L. weidemeyerii* Edwards \times *L. archippus* hybrids (Cross, 1936, 1937; Simpson and Pettus, 1976) have also been recorded. Lab-bred equivalents of these wild hybrids are shown in Fig. 1.

In this paper we shall review these past records and will report records of nine other naturally occurring *Limenitis* hybrids involving *L. archippus*, a species broadly sympatric with other members of the genus. We will also present new information obtained from laboratory

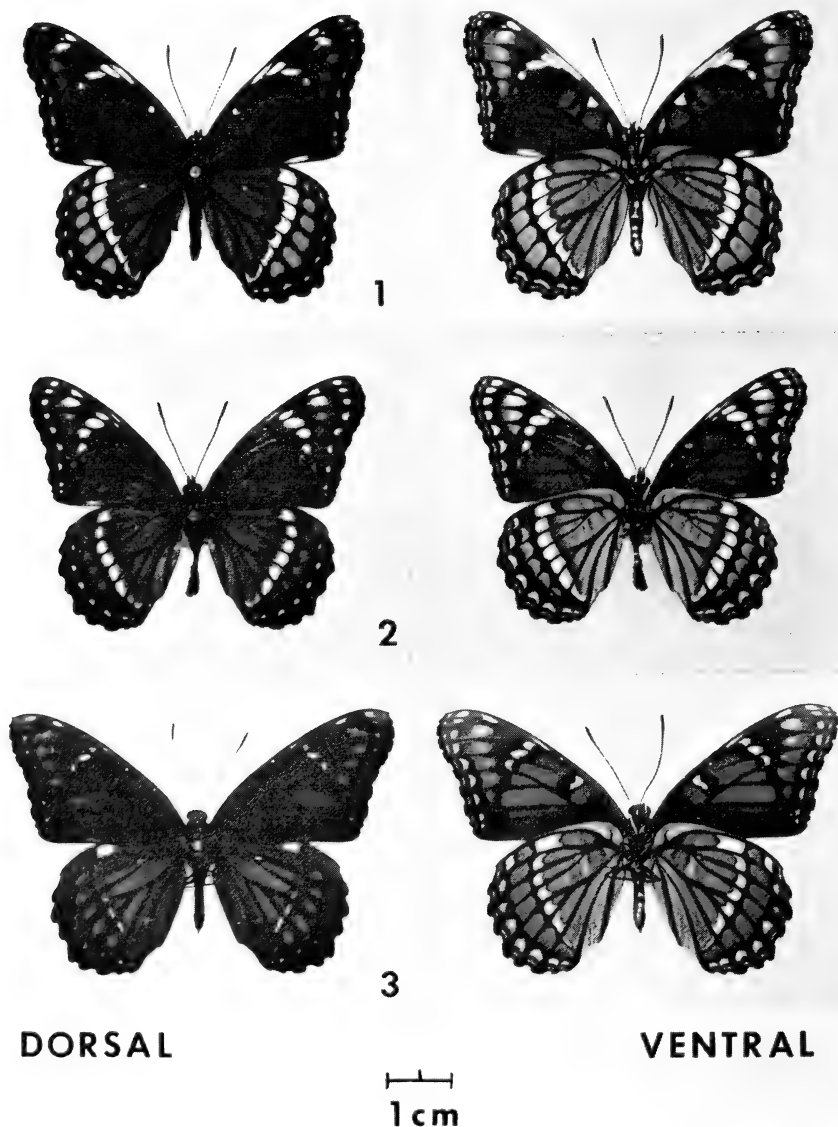


Fig. 1. Representative lab-bred F_1 male hybrid specimens. 1) Form "*arthechippus*," brood 893, No. 17, May 7, 1977; 2) form "*weidechippus*," brood 576, No. 7, Sept. 4, 1971; 3) *lorquini* ♀ × *archippus* ♂ (unnamed hybrid), brood 987, No. 1, Sept. 8, 1978. These, and all other lab-bred specimens, were reared on either *Salix babylonica* L. or *Prunus serotina* Ehrh.

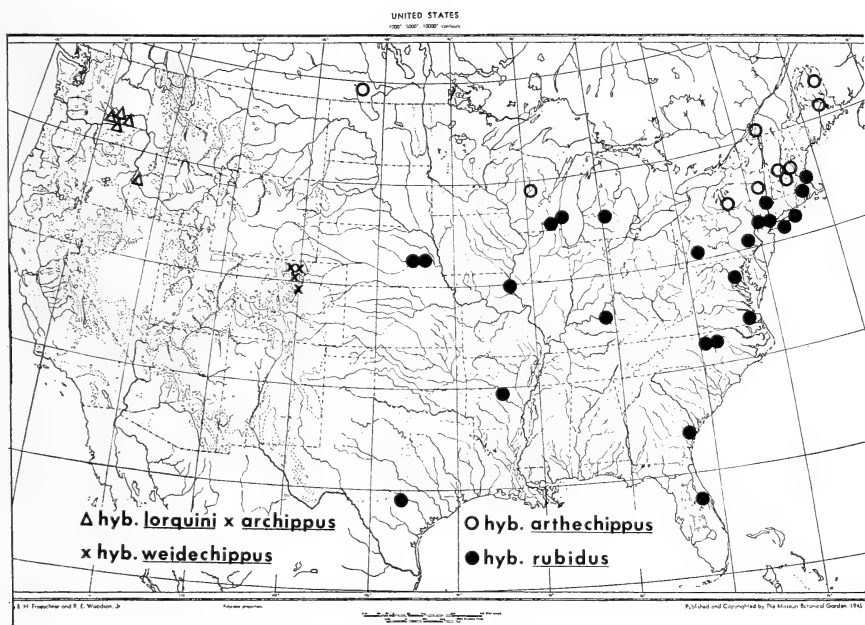


Fig. 2. Distribution map of 43 known wild, inter-specific F_1 hybrids involving cross-breeding with *L. archippus* collected from "prior to 1872" through 1976. All records for which the sex is known are males. These hybrids are widely distributed geographically. Touching symbols represent two (or more) specimens from the same locality. Most hybrids have been collected late in the season (August–November). Complete data for these hybrids are given in Tables 1, 1A, and 2. (Map reproduced with the permission of the Missouri Botanical Garden, St. Louis, Mo.).

crosses recently made by Platt, followed by a brief discussion of the relationships between *L. archippus* and its close relatives.

Tables 1, 1A and 2 summarize the collection data for all 43 records of wild hybrids involving *L. archippus* and its congeneric species. The geographic distributions of the various hybrid forms have been plotted in Fig. 2. The new hybrid locality records given in Table 1 are those from Maine (hyb. form "*arthechippus*" Scudder), Wisconsin, Illinois, Michigan, New Jersey, Virginia, and Florida (hyb. form "*rubidus*" Strecker). The specimens from Idaho, Illinois, Michigan, New Jersey, Virginia, and Florida probably represent state records for these hybrids.

The Florida record represents the first report of a natural hybrid between *L. a. astyanax* Fabricius and the sub-species *L. archippus floridensis* Strecker. The live specimen was observed circling a shrub willow along the edge of Mud Lake by G.W.R. while he was lunching

TABLE 1. Fourteen records¹ of naturally occurring inter-specific hybrids between the *limenitis arthemis-astyanax* complex \times *L. archippus* (See Table 1A for previous records).

State	County	Locality or Township	Date	No. & Sex	Collector &/or collection	Source and notes
1) ² Maine	Aroostook	<i>L. a. arthemis</i> \times <i>L. archippus</i> ("archippus" Scudder) So. of Castle Hill	Sept. 8, 1971	1 ♂	J. D. Zelig; pers. coll.	J. D. Z., pers. comm.
Wisconsin	Portage	Stevens Point	July 6, 1961	1 ♂	J. M. Malick; Milw. Co. Mus.	Johnson (1974)
2) Wisconsin	Milwaukee	<i>L. a. astyanax</i> \times <i>L. archippus</i> ("rubidus" Strecker) RR tracks vic. Estabrook Park	Aug. 9, 1971	1 ♂	R. Borth; pers. coll.	G. Balogh
3) Wisconsin	Walworth	Troy, W. of Lulu Lake	Aug. 8, 1976	1 ♂	G. Balogh; pers. coll.	G. Balogh
4) Illinois	Adams	Quincy, nr. Electric Wheel Plant	Sept. 29, 1960	1 ♂	A. Hunter; E. C. Tryon coll.	D. Hess & E. C. Tryon, pers. comm.
5) Michigan	Clinton	—	Aug. 20, 1974	1 ♂	J. R. Johnson; Entomol. Mus., Mich. St. Univ.	M. C. Nielsen, pers. comm.
6-7) New Jersey	Hudson	Kearny	June 21, Aug. 14 (yrs. not given; circa 1880-1910)	2 ♂ ♂	C. Leonhardt; U.S.N.M.	U.S.N.M. coll.; both bear Brooklyn Mus. labels; one has Barnes Coll. and Accen- sion 11782 labels, as well
—	—	Washington, D.C.	Not known	1 ♂	E. Shoemaker; Acad. Arts & Sci., Brooklyn, N.Y.	Newcomb (1907)

TABLE 1. Continued.

State	County	Locality or Township	Date	No. & Sex	Collector &/or collection	Source and notes
8) Virginia	Suffolk	Washington Ditch Great Dismal Swamp	Sept. 3, 1976	1 ♂	B. N. Hartgroves; U.S.N.M.	B. N. Hartgroves, pers. comm.
No. Carolina	Durham	So. of Durham	Oct. 10, 1970; Oct. 15, 1972	2 ♂ ♂	J. C. Greenfield, Jr., A.M.N.H., A.P. Platt coll., respectively	Platt & Greenfield (1971) Greenfield & Platt (1974)
Georgia	Chatham	Savannah	Sept. 22, 1974	1 ♂	R. T. Arbogast; pers. coll.	Arbogast (1976)
9) Florida	Volusia	Lake Woodruff Wildl. Refuge, vic. Mud Lake	Nov. 22, 1974	1 ♂	G. W. Rawson; U.S.N.M.	G. W. Rawson

¹ This table excludes 20 records previously listed by Platt and Greenfield (1971).

² Numbered records have not been previously reported by Newcomb (1907), Platt and Greenfield (1971), Greenfield and Platt (1974), Johnson (1974), or Arbogast (1976).

TABLE 1A. Records of 20 previously wild-caught *Limenitis arthemis-astyanax* hybrids, modified from Platt and Greenfield, 1971: 280. Dashes indicate that information was not available. (Reproduced by permission of the authors.)

Province or State	County	Locality or Township	Date	No. & Sex ¹	Collector &/or collection	Source and notes
<i>L. a. arthemis</i> × <i>L. archippus</i> ("archeippus" Scudder) ²						
Quebec	—	Chateauguay Basin vic. Montreal	Sept., 1879	1 ♂	J. G. Jack	Edwards (1882); Scudder (1889)
Maine	Penobscot	Passadumkeag	"many years ago" (2nd brood)	1	L. P. Grey	Grey (1968)
New Hampshire	Cheshire	Alstead	1895, 1896, 1902 (seen)	3 ♂ ♂	W. L. W. Field	Field (1904)
Manitoba	—	Beulah	June 29, 1904	1 ♂	A. J. Dennis	Gunder (1934)
New York	Tompkins	Dryden	Aug. 6, 1967	1 ♂	A. M. Shapiro	Shapiro and Biggs (1968)
New York Total	Albany	East Berne	Aug. 8, 1938	1 ♂ 8	E. Statsinger	F. H. Rindge
<i>L. a. astyanax</i> × <i>L. archippus</i> ("rubidus" Strecker) ³						
Pennsylvania	Berks	—	Prior to 1872	1 ♂	T. L. Mead, F.M.N.H. Coll.	Gunder (1934)
Pennsylvania	Westmoreland	Jeanette	—	1 ♂	Barnes coll., U.S.N.M.	Gunder (1934)
Massachusetts	Norfolk	Wellesley	—	1 ♂	A.M.N.H. coll.	Gunder (1934)
Massachusetts	Middlesex	Sherborn	Aug., 1896	1 ♂	A. L. Bablock	Gunder (1934)
New York	—	Brooklyn	Sept. 9, 1913	1 ♂	Barnes coll., U.S.N.M.	Gunder (1934)
New York	"Eastern" (Catskills?)	—	—	1	—	Shapiro and Biggs (1968)

TABLE 1A. Continued.

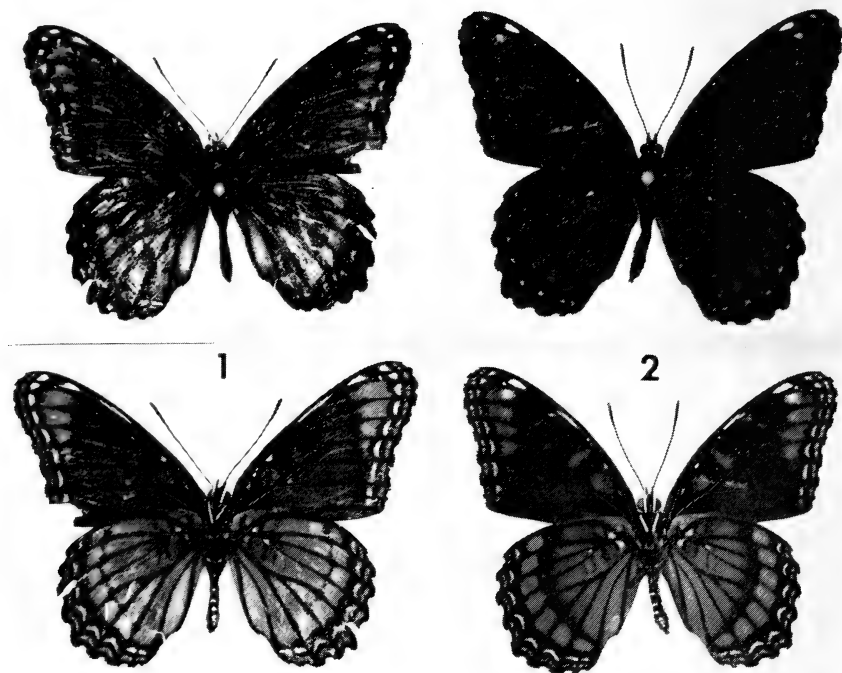
Province or State	County	Locality or Township	Date	No. & Sex ¹	Collector &/or collection	Source and notes
New York	—	Long Island	—	1 ♂	Jacob Doll	Field (1904)
Kentucky	Jefferson	Louisville	Sept., 1948	1 ♂	R. Steilberg & J. Smith	Monroe (1953)
Arkansas	Pulaski	Rose City	Sept. 1, 1933	1 ♂	A.M.N.H. coll.	F. H. Rindge
Nebraska	Platte	Columbus	Sept. 4, 1963	2 ♂ ♂	E. A. Froemel	K. Johnson
Texas	Bexar	San Antonio	Sept. 22, 1970	1 ♂	J. F. Doyle III	J. F. Doyle III
Total				12		

¹ Insofar as is known, all specimens collected to date have been males.

² Eight male *arthechippus* were reared by Field (1914) from an *L. archippus* ♀ × *L. a. arthemis* ♂ cross. Other reciprocal crosses have been made recently by Platt.

³ A ♀ *L. a. asfyanax* × ♂ *L. archippus* were collected in copula Aug. 26, 1957 in a barnyard by Mrs. H. E. Hanna at El Dorado, Union Co., Arkansas. The two specimens are in the A.M.N.H. (Klots, 1959; Dr. F. H. Rindge, pers. comm.).

DORSAL



VENTRAL

1 cm

Fig. 3. 1) Wild-caught and 2) lab-bred male specimens of *L. arthemis astyanax* \times *L. archippus floridensis* F₁ hybrids (form "rubidus"). Data for the lab-bred specimen are brood 986, No. 1, Sept. 19, 1977 (Data for wild-caught specimen are given in Table 1).

with members of the Florida Audubon Society in the northeastern portion of the Ocala National Forest. He recognized the specimen as an "off-color" *Limenitis* and investigated it further. The insect then settled on the willow shrub. Since he had no net, George made a "desperate strike" at it with his cap, knocking the butterfly to the ground and collecting it. The specimen is illustrated in Fig. 3, along with a similar, single specimen recently reared by A.P.P. in the laboratory from a hand-paired cross between a Maryland *astyanax* \times a *floridensis* σ (from a stock obtained just east of the Everglades [near Home-

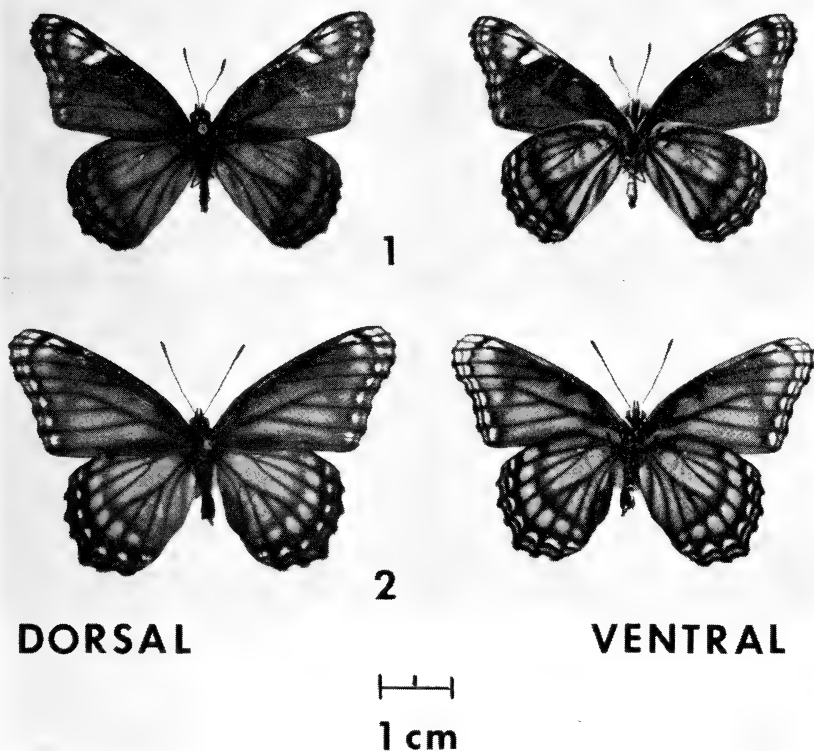


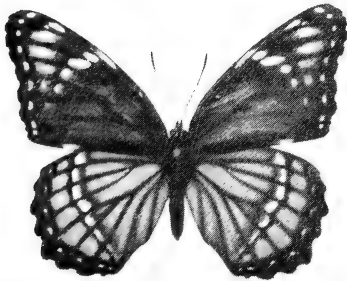
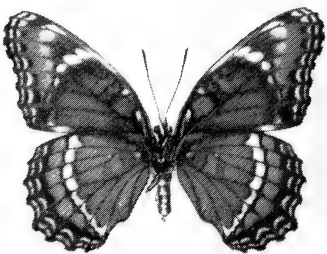
Fig. 4. Small, weak, and faded lab-bred F_1 female hybrid specimens, dorsal and ventral views. 1) Form "*weidechippus*," brood 576, No. 1, Aug. 28, 1971; 2) form "*rubidus*," brood 648, No. 4, July 26, 1973.

stead] in southern Florida). *Astyanax* evidently is relatively uncommon in central Florida. Near his home at New Smyrna Beach (Volusia Co.), G.W.R. has seen only two specimens of *astyanax* during the past 20 years. Also, F. Rutkowski (pers. comm.) recently collected a ♂ *astyanax* 1.5 miles north of Shamrock (Dixie Co.) in Florida, and he mentioned other records from as far south as Dade Co. (Kimball, 1965). Possibly such scarcity of one (or both) species accounts in part for such inter-specific hybridization (Simpson and Pettus, *loc. cit.*).

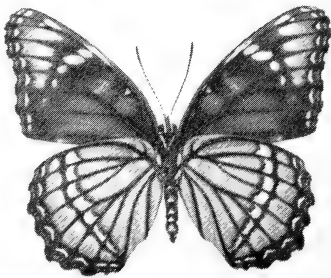
So far as is known, all of the wild hybrids thus far collected have been males, although five broods containing small, faded, weak (and often malformed) F_1 females (Fig. 4) were reared at UMBC in June and July, 1973 by crossing inter-specific strains having different geographic origins (Maryland *L. astyanax* ♀♀ × Vermont *L. archippus*



1



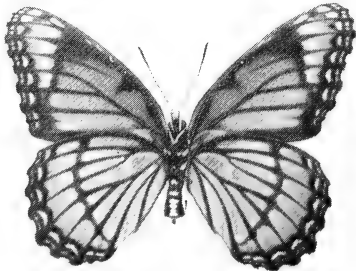
2



3



4



DORSAL

VENTRAL



♂ ♂). Among these broods, there were a total of 39 (27%) F_1 females among 143 hybrid "*rubidus*" progeny. Two of the larger broods, involving sibling female *astyanax* and the same male *archippus* parent, yielded 1:1 sex ratios.

Earlier crosses reported by Platt (1975) showed that such inter-specific crosses, in which strains from the same (or closely adjacent) northeastern geographic origins were crossed, gave rise to complete adult heterogametic (female) inviability. However, robust females of the "*arthechippus*" and "*rubidus*" hybrid phenotypes (Fig. 5) also have been obtained by backcrossing F_1 hybrid males to females of the three parental forms (*arthemis*, *astyanax*, and *archippus*, respectively). Such backcrosses often have low viability, but sometimes yield relatively large numbers of progeny (Platt, *loc. cit.*). Although fertile crosses have been obtained in all possible reciprocal combinations, crosses using *L. arthemis*, *astyanax*, *lorquini*, or *weidemeyerii* ♀♀ × *L. archippus* ♂♂ have been the easiest to effect in the laboratory using hand-pairing. The fact that such a pairing also has been seen in the wild (Klots, 1959; Table 1A) suggests that these inter-specific hybrid crosses may occur most often in this direction in nature, as well.

Table 1 indicates that eight of the nine previously unreported *arthemis-astyanax* × *archippus* hybrids, like most of those reported earlier, were collected during the late summer and fall months (August–November). Only one (from New Jersey) was collected in June, a time suggesting that it most likely arose from an over-wintering larva. Thus, these new records, as well as the previous ones, support the contention that the ecological and behavioral barriers normally preventing inter-specific hybridization in *Limenitis* tend to break down later in the season (Greenfield and Platt, *loc. cit.*). This break down may well be correlated with the onset of facultative larval diapause in *Limenitis* which occurs during the third instar. Thus, it seems as if those individuals most often selecting mates of the wrong species are the very ones which seem to be "genetically mal-adapted" to their environment (that is, they are the ones which are not diapausing at that time of year when they are

←

Fig. 5. Representative robust, lab-bred hybrid-type backcross females. 1) *L. arthemis* ♀ × F_1 hybrid "*arthechippus*" ♂ ("*arthechippus*-like" morph), brood 63c, No. 4, July 30, 1968; 2) *L. archippus* ♀ × F_1 hybrid "*arthechippus*" ♂ ("*arthechippus*-like" morph), brood 915, No. 45, June 13, 1977; 3) *L. arthemis* ♀ × F_1 hybrid "*rubidus*" ♂ ("*proserpina*-like" morph), brood 95B, No. 4, Dec. 26, 1968; 4) *L. archippus* ♀ × F_1 hybrid "*rubidus*" ♂ ("*rubidus*-like" morph), brood 757, No. 10, Sept. 15, 1975. Such backcross females also occur in parent-type morphs (see Platt, 1975).

TABLE 2. Records of nine wild hybrids involving the two western banded species of *Limenitis* (*lorquini* and *weidemeyeri*, respectively) \times *L. archippus*.

State	County	Locality or Township	Date	No. & Sex	Collector &/or collection	Source and notes
<i>L. lorquini</i> \times <i>L. archippus</i> (unnamed form)						
Washington	Benton	Richland, nr. Richland "Y"	July 4, 1965	1 ♂	E. V. Gage, pers. coll.	Gage, 1970; Perkins and Gage, 1970
Washington	Benton	Richland, nr. Richland "Y"	July 6, 1969	2 ♂ ♂	J. C. Montgomery, pers. coll.	Gage, pers. comm.
Washington	Benton	Richland, nr. Richland "Y"	Sept. 4, 1971	1 ♂	J. C. Montgomery, pers. coll.	Gage, pers. comm.
Idaho	Ada	nr. Lucky Peak Dam	Oct. 7, 1971	1 ♂	R. Cassingham, pers. coll.	Gage, pers. comm.
<i>L. weidemeyeri</i> \times <i>L. archippus</i> (" <i>weidechippus</i> " Cross)						
Colorado	Lorimer	Fort Collins	Aug. 25, 1894	1 ♂	C. P. Gillette, C.S.U. Entomol. Mus.	Simpson and Pettus (1976)
Colorado	Lorimer	Fort Collins	June 9, 1973	2 ♂ ♂	R. G. Simpson	Simpson and Pettus (1976) 1 caught; 1 seen; fresh; presumed sibs
Colorado	Not given	nr. Denver along Platte R.	circa 1936	1 ♂	C. D. Schryver; pers. coll.	Cross, 1936; 1937

supposed to be doing so). Such hybridization, perhaps, represents a "last chance" effort to reproduce.

The similar rare natural hybrids reported between both of the western banded *Limenitis* (*L. lorquini* and *L. weidemeyerii*) and *L. archippus* are listed in Table 2. The eight known dates of siting or capture suggest once again that either 1) the hybrids emerged early enough in the year (June and July dates) so that it is a relative certainty that the larvae from which they arose over-wintered in hibernacula, or 2) the specimens were collected in the late summer or fall months. Gage's (pers. comm.) collection dates for the small "hybrid swarm" near Richland, Washington (Table 2) suggest that the four *lorquini* \times *archippus* hybrids, in fact, represent progeny from at least three different matings. The same may be said for the four "*weidechippus*" records from Colorado, as well. All of these wild western hybrids are males, and they closely resemble hybrid from "*arthechippus*" in possessing a partial postmedial white band dorsally (Fig. 1). Two crosses between Colorado *weidemeyerii* $\text{♀♀} \times$ Massachusetts *archippus* ♂♂ have been made by laboratory hand-pairings to date, yielding 22 ♂♂ and nine ♀♀ (seven of the latter being malformed). All of these F_1 's, although showing some phenotypic variability, are referable to hyb. form "*weidechippus*" (Platt, unpub. data). During the past summer two crosses between Oregon *L. lorquini* $\text{♀♀} \times$ Maryland *L. archippus* ♂♂ were carried out. All 16 F_1 progeny were males. An additional cross involving an F_1 hybrid, *arthemis-lorquini* ♀ (Massachusetts \times Oregon stocks, respectively) \times Maryland *archippus* ♂ , yielded 21 male hybrid-like progeny.

Thus, *L. archippus*, which is broadly sympatric with its congeners, will occasionally hybridize with all of the other allopatric species of *Limenitis* in nature. However, such crosses evidently are rare, leading to the supposition that morphological, behavioral, visual, and possibly pheromonal cues, as well as habitat isolating mechanisms, normally operate to prevent such inter-specific hybridization. These barriers against gene exchange between the viceroy and its close relatives sometimes tend to break down, usually when one or both species are rare, and often toward the end of the breeding season, at times when the majority of developing *Limenitis* larvae are entering diapause.

Laboratory data show that inter-specific strains having different geographic origins may be genetically more compatible than similar strains from the same locality, as judged by either the presence or absence of adult females in the F_1 generation. Thus, genetic incompatibility between the viceroy and its congeneric species is viewed as being of local

origin, suggesting that *archippus* may have arisen from a banded ancestral species by the process of sympatric speciation. (The senior author would appreciate hearing from members of the Society who may have knowledge of other records of wild *Limenitis* hybrids.)

ACKNOWLEDGMENTS

We are grateful to those individuals who provided us with information regarding the collection of hybrid specimens as noted in Table 1. We thank Dr. A. Maizels for sending the *floridensis* stock and Mr. P. J. Kean for making the inter-specific hand-pairing involving this strain. Mr. S. J. Harrison and Mr. T. Williams have assisted with the insect rearing and preservation. We thank Dr. W. D. Field, Dr. D. C. Ferguson of the U.S.N.M., and Dr. K. Bagdonas of the University of Wyoming for the information relating to hyb. form "*weidechippus*". Mr. E. Gage kindly provided data and color photos of the *lorquini* × *archippus* hybrids.

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TAENIDIA INTEGERRIMA, A NEW FOODPLANT RECORD FOR PAPILIO POLYXENES (PAPILIONIDAE)

Host plants recorded for the larval stages of *Papilio polyxenes* Fabricius include a wide variety of species in the family Umbelliferae. Although the dominant foodplants in the northeastern United States are plants naturalized from Europe, e.g., *Daucus carota* Linnaeus and *Anethum graveolens* L. (Tyler, 1975, The Swallowtail Butterflies of North America, Naturegraph Publishers, Heraldsburg, CA), a number of endemic species have been documented as foodplants. Tietz (1972, An Index to the Described Life Histories, Early Stages, and Hosts of the Macrolepidoptera of the Continental United States and Canada, A. C. Allen, Sarasota, FL) lists *Cicuta bulbifera* L., *Cicuta maculata* L., *Angelica atropurpurea* L., *Osmorhiza claytoni* (Michx.), *Osmorhiza longistylis* (Torr.), *Oxypolis filiformis* (L.), *Spermolepis divaricata* (L.), *Ptilimnium capillaceum* (Michx.), and *Sium suave* Walt. among the native umbellifers; *Cryptotaenia canadensis* (L.) has recently been reported as a foodplant as well (Scriber and Finke, 1978, J. Lepid. Soc. 32: 236-238). The majority of these species are characteristically found in rich damp woods (*Osmorhiza* spp.) or wet thickets and swamps.

The native umbellifer *Taenidia integerrima* (L.) Drude (yellow pimpernel), hitherto unrecorded as a host plant for *P. polyxenes* but reported as a host plant of the recently described sibling species *P. joanae* (Heitzman, 1973, J. Res. Lepid. 12: 1-10), is a plant of dry, gravelly slopes and rocky hillsides (Fernald, 1950, Gray's Manual of Botany, 8th ed., American Book Co., NY). On June 22, 1977, one fifth instar larva of *P. polyxenes* was found feeding in a patch of *T. integerrima* growing on a dry, exposed slope bordering a road which cuts through Coy Glen, a forested area 3 km west of Ithaca, Tompkins Co., New York. Two additional fifth instar caterpillars were found in the same patch two days later. All three caterpillars were collected and reared to pupation on *T. integerrima* collected from the Coy Glen site. Pupation was virtually synchronous on June 24, 1977, indicating that the caterpillars may have developed from eggs laid at approximately the same time, possibly by a single female. On July 2, 1977, one adult male ichneumonid, *Trogus pennator* (Fabr.), a well-known parasitoid of *P. polyxenes* (Heinrich, 1964, Canad. Ent. Suppl. 29: 807-853), emerged from each of the three pupae.

Scriber (1975, doctoral dissertation, Cornell University) reports that, under laboratory conditions, *T. integerrima* supports the growth of *P. polyxenes* as well as (or better than) most of its commoner foodplants. Moreover, females confined over the plant oviposit freely on it (M. Berenbaum and M. Rausher, pers. obs.). The dearth of records for *P. polyxenes* on yellow pimpernel in the wild is therefore intriguing. Habitat unsuitability might be one explanation. *P. polyxenes* does not normally fly in deep woods (Tyler, 1975, *op. cit.*), where *T. integerrima* is found, and thus is not likely to encounter the plant. In this particular instance, the plants were growing along a road cut through thick woods approximately 0.4 km from an open field supporting a luxuriant growth of *Conium maculatum*, a well-documented host plant for *P. polyxenes* (Tietz, 1972, *op. cit.*). Road cuts are known to act as flyways for *P. polyxenes* (Heitzman, 1973, *op. cit.*) and, in this case, might have directed an ovipositing female out of open field habitat into deep woods, where she might otherwise not fly.

Especially interesting with respect to these findings are two other reports of *P. polyxenes* on plants in heavily wooded areas. Scriber and Finke (1978, *op. cit.*) observed an oviposition on *Cryptotaenia canadensis* growing in a narrow wooded strip in an otherwise open residential area, and Rehr (1973, J. Lep. Soc. 27: 237-238) reported the occurrence of *P. polyxenes* larvae on another deepwoods plant, *Thaspium barbinode* (Michx.), which was growing along a road cut on a dry bank. *T. barbinode*, like *Taenidia integerrima*, is a purported host of the newly described *P. joanae* (Tyler, 1973, *op. cit.*). In view of the ability of *P. polyxenes* to exploit both *P. joanae* hostplants and habitat, and given the enormous variability in both larval and adult coloration within the species (M. Berenbaum, W. Blau, L. Contardo and P. P. Feeny, pers. obs.), it might well be premature to assign species status to *P. joanae* without first examining the extent to which habitat has contributed to reproductive isolation in areas where *P. joanae* is reported to occur.

I thank Ken Sandlan of the Cornell University Entomology Department for identifying the ichneumonids (deposited along with the *P. polyxenes* chrysalids in Cornell University Collection Lot 1023, Sublot 41a) and W. Blau and P. P. Feeny of the Department of Ecology and Systematics at Cornell for confirming the identification of the caterpillars. This work was supported in part by N.S.F. Research Grant DEB 76-20114 AO1 to P. P. Feeny.

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MID-VALVAL FLEXION IN THE LEFT VALVA OF ASYMMETRIC GENITALIA OF ERYNNIS (HESPERIIDAE)

The left and right sides of *Erynnis* (*Erynnides*) Burns genitalia often differ grossly in shape (Burns, 1964, Univ. Calif. Pub. Entomol. 34). On a hilltop at Red Rocks, Jefferson Co., Colorado on 21 June 1973, I noticed that the male of a copulating pair of *E. pacuvius* (Lintner) seemed to squeeze the female's abdomen repeatedly with his valvae for several minutes before copulation ended. A copulating pair of *E. persius* (Scudder) was then found, and was observed more closely. Mating lasted 38 minutes, and during the last 25 min. at least, the male scraped his left valva

over her convex 7th sternum, by actually bending the valva in the *middle* such that the long ventral process and short middle process bent medially, but the base of the valva and the right valva were relatively stationary.

On a hilltop at Jarre Canyon, Douglas Co., Colorado on 26 May 1978, I observed a copulating pair of *E. persius* in which the male scraped his left valva over the female sternum 7 for 30 min. from capture until both were killed and microscopically examined while still joined. This pair was examined very closely while in copula. The male and female abdomens were inclined upward, forming an angle of about 150° ventrally to each other. The male's uncus fit over the posterior rim of the female lamella, and beneath the papilla analis. The lower process of the right valva pressed the membrane above the female sternum 7. The upper process of the right valva was not visible but probably hooked over the right edge of the lamella. The upper process of the left valva hooked dorsally over the right edge of the female sternum 7. The middle and lower process, however, were flexed medially about 30° over the ventral surface of sternum 7, and were flexed medially another 30° during each flexion at intervals of about 1 per sec. The female dorsal belt of "scent scales" was exposed to view during copulation; the ventral hair pencils were also exposed (but not expanded), and approximately 2 mm of sternum 7 were exposed to view. With each flexion of the middle and lower processes of the left valva, scraping across the female sternum 7 occurred, and the lower process of the right valva pressed the female membrane above sternum 7 inward, while the exposed 2 mm length of sternum 7 shrank to 1.5 mm as the male's abdomen telescoped slightly. The male abdomen exhibited squeezing movements with the valva about 1 per sec. but not peristaltic movements. When dissected, the female was found to have a full-sized spermatophore with the usual complement of transparent granules, milky bulb, and partly formed neck.

Female *Erynnis* genitalia are somewhat unusual in that sternum 7 is nearly as heavily sclerotized as the lamella. The lamella is partly telescoped under sternum 7 during copulation, and the male *persius* scrapes sternum 7 with his left valva over the bulge on the right side of the asymmetric female lamella. It is noteworthy that genitalic asymmetry is developed strongly only in subgenus *Erynnides* and not strongly in subgenus *Erynnis* Schrank (Burns 1964, op cit). Most members of subgenus *Erynnis* probably do not exhibit valval scraping because Burns states that sternum 7 of females is densely scaled in all species except *icelus* (Scudder & Burgess). Asymmetry of genitalia therefore seems associated with asymmetric valval flexion during copulation. The function of valval scraping is unknown. The hair pencils were intact after mating of these females and are intact in most museum specimens which have mated. These observations are reported here because mid-valval flexion is, to my knowledge, completely unknown in Lepidoptera, and hopefully this note will stimulate others to help elucidate the function of this strange behavior.

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EDITOR'S NOTE:

While carrying out numerous intra- and inter-specific hand-pairings of *Limenitis* during the past 12 years, I have often observed the process of copulation in this genus. During mating, it is usual for the males to exhibit mid-valval flexion of the type described above by Dr. Scott. Such observations can be made using a stereomicroscope without disturbing the mating pair. Both valvae can be seen to flex inward, perhaps serving to stimulate the female by raking the distal teeth (or hooks) across her lateral abdominal sternae. The valvae of *Limenitis* are symmetrical, except for the placement and number of teeth on the distal tips of the claspers (see Platt, Frearson, & Graves 1970, *Canad. Entomol.* 102: 513-533).

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CATOCALA ILIA (NOCTUIDAE) FEEDING ON DECAYING FRUIT IN AN INNER-CITY ENVIRONMENT

The feeding of adult Lepidoptera on over-ripe fruit has been noticed for at least two centuries, but some recent observations may be of value and interest because they incorporate data about diurnal activity of a nocturnal moth as well as occurrence in an inner-city environment.

Occasional accounts have appeared of daytime flight of *Catocala*, yet adult feeding of this genus has generally been regarded as crepuscular and nocturnal. Moreover, little is known about the occurrence of *Catocala* in cities of some size, although it appears that the moths may be found in large numbers in such situations; for example, I have described Bryant Mather's collecting of 124 specimens (15 species) within two days in downtown Jackson, Mississippi (Wilkinson 1971, Michigan Entomol. 4: 59-60). In seven years of residence on Capitol Hill, Washington, D.C., I have found *Catocala* in abundance, but not as numerous in specimens or species as in Mather's situation. Although I have taken so rare a species as *C. marmorata* Edw. (daylight, at rest on a wall of the Library of Congress near an entrance lamp, 27 July 1977), the most common species of inner-city Washington is *C. ilia* (Cramer).

Seated in my enclosed back garden on 22 August 1976, while the sun was shining, I noticed a large *Catocala* fly into the grape arbor at 1400. Upon searching, I found a male *C. ilia* feeding at a cluster of over-ripe and broken Concord grapes. When leaving the extensive arbor I flushed another *Catocala* which was not captured but was quite probably *C. ilia*.

In 1977, several ornamental Oriental peach trees in my back garden threw down their first extensive crop of many hundreds of small peaches. I was unable to attend to gathering all of these immediately, and a number began to decay. At the same time I noticed an abnormal frequency of *C. ilia* on my windows and about my security floodlight at night. Walking into the garden with a flashlight at 0200 on 2 July I disturbed numerous *C. ilia* (many of which were taken, identified and released) feeding on the decaying peaches. With these hints in mind, on 4 July I kept a long watch in my garden, having purposely left peaches on the ground. At approximately four hours before dusk I noticed the first *ilia* flying in the garden. From that time until dark, *C. ilia* were sighted in flight at 20 to 40 minute intervals. I was able to trace perhaps 50% of these individuals, always to or near rotting peaches. Diurnal and nocturnal feeding continued into early August, until fallen peaches were no longer edible.

These observations not only suggest further opportunities for study of diurnal flight and feeding of *Catocala*, but indicate the desirability of more extensive research into the occurrence of the genus in urban areas. My data on *Catocala* in Washington, D.C. continue to accumulate.

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PERIODIC OCCURRENCE OF *URANIA FULGENS* (URANIIDAE)
IN THE UNITED STATES¹

In a recent literature search I came across a one-page article by Leussler (1918, Entomol. News 29:149) titled, "Interesting butterfly occurrences at Beeville, Texas." The first species listed is, "*Cydimon poeyi* Gundlach—One specimen of this tropical swallowtail was captured by Miss Pattie Hutchinson at Beeville, June 17, 1916." Leussler cited Felder & Felder [1864-1875, Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857-1859. Zool. Theil 2 (7)], as giving an illustration of the species which Miss Hutchinson had collected.

Confusion resulted from Leussler's report, first from the term "butterfly," and second from incorrect nomenclature. The oldest valid generic name (D. C. Ferguson, pers. com.) is *Urania* Fabricius, 1807, not *Cydimon* Dalman, 1824. The nomenclature was further confused by the use of the species name *poeyi* Gundlach, of Cuban origin, and superficially close to *fulgens* according to Gaede [1930, in Seitz, The Macrolepidoptera of the World, 6:820-831 (*Urania*). Alfred Kern Verlag, Stuttgart], and only doubtfully distinct (D. C. Ferguson, pers. com.). Thus, what Miss Hutchinson actually caught was *Urania fulgens* Walker.

The purpose of this paper is not to make or propose taxonomic changes, but rather to present the true identity of the specimen recorded by Leussler, and to document other occurrences of the species within the United States. The specimen which Miss Hutchinson captured (Fig. 1) is now in the USNMNH together with two other examples from Texas, one of which is illustrated (Fig. 2). Interestingly, McDunnough [1938, Mem. So. Calif. Acad. Sci. 1 (1)] did not include this genus or species in his check list, possibly because Leussler's report of 20 years earlier had not come to his attention.

Of the 10 examples of this species collected in the United States over the past 60 years, all except one are from Texas. A migration of this species in Texas also is recorded. Perhaps there are other existing examples in collections just waiting to be brought to light. Data on the known examples follow:

FLORIDA: 1 ♂, worn, 9 September 1973, Fort Walton Beach, Okaloosa Co., V. J. Farkas (Emmel & Farkas 1974, J. Lepid. Soc. 28:292) (in Kendall collection). TEXAS: 1 ♀, worn, 17 June 1916, Beeville, Bee Co., Miss Pattie Hutchinson (Leussler 1918, cited above) first U.S. record; 1 ♀, worn, 8 April 1941, Lancaster, Dallas Co., Mickey Lemmon; 1 ♀, worn, 11 April 1941, Lancaster, Dallas Co., H. A. Freeman (these 3 specimens in the USNMNH); 1 ♂, worn, 6 April 1941, nr. San Antonio, Bexar Co., C. O. Neumann (in Kendall collection, ex coll. A. E. Brower); 1 ♀, worn, 27 December 1955, College Station, Brazos Co., no coll. label (in Texas A&M Univ. collection); 1 ♀, worn, 5 September 1971, George West, Live Oak Co., John E. Hafernik, Jr., and in his collection; 1 ♀, in sealed mount, W. W. White Elementary School, San Antonio, Bexar Co. (a recent inquiry disclosed the specimen no longer exists); 2, sex undetermined, 1 in good condition, the other fair, July 1939, San Benito, Cameron Co., Jack B. Prentiss (given to his high school; recent inquiry discloses they no longer exist).

Gaede (1930, cited above) gave brief descriptions of the larva and pupa for *U. leilus*, but made no mention of a larval foodplant. Beutelspacher (1972, J. Lepid. Soc. 36:133-137) found a cocoon of *U. fulgens* in Mexico among the leaves of an epiphytic bromeliad growing on the trunk of a coconut palm. Smithsonian Institution Research Reports No. 7, Winter 1974, and Neal G. Smith (pers. com.) confirm *Omphalea diandra* L., Euphorbiaceae, as a larval foodplant for *U. fulgens*; this is a difficult plant to find because of its climbing habit and foliage production high in the forest canopy.

Although little has been published on the life history of the uraniids, much has

¹ Contribution No. 399. Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville 32602.



Figs. 1-2. *Urania fulgens*, females. 1, first United States record, Beeville, Bee Co., Texas, 17 June 1916, *leg.* Pattie Hutchinson. 2, Lancaster, Dallas Co., Texas, H. A. Freeman, 8 April 1941, *leg.* Mickey Lemmon.

been published on the migratory habits of these moths. Gaede (1930, cited above) gave general migratory habits of the genus, but indicated that they do not reach the United States; no doubt Leussler's report had not come to his attention. Williams (1937, *Nat. Geog. Mag.* 71:568-585) gave Mexico, Nicaragua, Costa Rica, and south to Ecuador as the migratory area. Valerio G. (1966, *Univ. Costa Rica journal*, *Cratera* 1:40-45) gave the period, magnitude, direction, and speed of flight, and mentioned an attraction to shiny objects. He indicated also that *U. fulgens* migrated in Veracruz, Mexico; Atlantic coast of Honduras, Rivas isthmus of Nicaragua, Panama, and Bogota area of Colombia. He speculated that the larvae may feed on tree-top foliage, thus avoiding detection by collectors. Young (1970, *J. N. Y. Entomol. Soc.* 78:60-70) documented the daily flight activities of *U. fulgens* in Costa Rica where an observed migration lasted 42 days; the life expectancy was estimated to be 28 days for males and 34 days for females. Smith (1972, *Carib. J. Sci.* 12:45-58) documented the population fluctuations and migrations of *Urania* moths in lower Central America, the Lesser Antilles, and in northern South America since 1868. He found no clear cut periodicity of movement, but the most frequent interval was 8 years.

In July 1939 at San Benito, Cameron Co., Texas, Jack B. Prentiss observed a migration of *U. fulgens* during the morning hours, in a pasture behind his home. In personal communication he stated, "The flight was rather extensive; there were always a few in sight for the better part of 4 hours. They were all flying in a due north direction. During the height of the flight they were rather numerous; 20 to 30 could be seen at one time. Most were flying too high to be netted and all were flying fast. Those flying low were most elusive and one had but a single chance to net them. During the course of the flight I did manage to take 2 specimens; one was in extremely good condition, the other only fair. Both specimens were placed in the high school collection. I have since checked to see if they were still there but found they have long since been discarded."

ACKNOWLEDGMENTS

For literature citations I am indebted to Cyril F. dos Passos, William D. Field, Thomas C. Emmel, and Kent H. Wilson. For specimens or for field information on

specimens, I wish to thank Thomas C. Emmel, John E. Hafernik, Jr., Richard S. Peigler, Jack B. Prentiss, and A. E. Brower. To Douglas C. Ferguson, I am especially grateful for providing not only data on the Texas examples in the National Collection, but also for the photographs used in this paper, for confirming the determination of the Florida specimen, and for reviewing the manuscript.

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A PARTIALLY ALBINIC ABERRATION OF *PHYCIODES THAROS* (NYMPHALIDAE)

On 25 July 1977, I took a partially albinic male aberration of *Phyciodes tharos* Drury (Fig. 1) in Upper Tyrone Township, Fayette Co., Pennsylvania, at an elevation of 1100 ft (335 m). All the normally tawny or brown coloration characteristic of this species was replaced by an extremely pale, orange-tinged cream color. The black markings were not affected. I know of no similar specimens. The aberration has been deposited in the collection of the Peabody Museum of Natural History, Yale University, New Haven, Connecticut.

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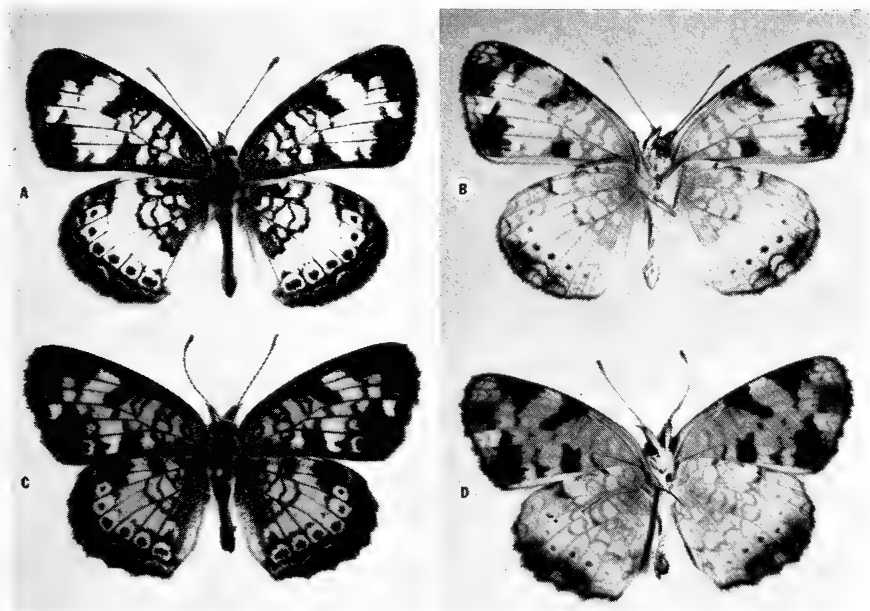


Fig. 1. *Phyciodes tharos* Drury: A., B. pale (partially albinic) male aberration, dorsal and ventral sides; C., D. typical male from same locality, dorsal and ventral.

A RECORD OF *AGRIAS AMYDON* (NYMPHALIDAE) FROM COSTA RICA

Two female specimens of *Agrias amydon* Hew. subspecies (?) were taken in Parque Santa Rosa, Guanacaste Province, Costa Rica. This is the first substantiated record of this genus from Costa Rica. *Agrias zenodorus smalli* Miller & Nicolay has been anticipated from Costa Rica and there exists in the literature a supposed sight record from Turrialba, Cartago Province, Costa Rica (Miller & Nicolay 1971. Bull. Allyn Mus. (1):1-5). It was totally unexpected to find *Agrias* in a habitat like Guanacaste where there is a strongly marked dry season in contrast to the usual wet forest habitats in other countries where the genus *Agrias* occurs.

I have compared the specimens with *A. amydon* in the U.S. National Museum, the Carnegie Museum, and the Allyn Museum of Entomology and have found them to be differently marked on the dorsal surface of both fore and hind wings than the comparative material. Description of this *A. Amydon* subspecies is impossible on the basis of only two female specimens and must await more material.

On the basis of the specimens examined in the above mentioned museums and in the literature available to me, *A. amydon* is recorded only as far north as Colombia. These specimens represent a considerable range extension and a new record for Costa Rica. One specimen has been placed in the collection of the Allyn Museum of Entomology, Sarasota, Florida.

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Fig. 1. *Agrias amydon* Hew., subspecies (?), female: dorsal (left), ventral (right). Wingspan = 6 mm.

ADDITIONAL FUNCTION OF THE LEPIDOPTERAN PROBOSCIS

The most unique part of the lepidopteran body form is the proboscis. This prehensile tube functions mainly as a suction device for nutrient procurement. A second, but minor, function has been observed in a variety of unrelated butterflies and moths

—fluid “pumping.” Reports describe these individuals as having an extended proboscis at a moisture source and simultaneously voiding fluid from the anus (Clench 1957, *Lepid. News* 11:18–21; Roever 1964, *J. Res. Lepid.* 3:103–120; Hessel 1966, *J. Lepid. Soc.* 20:242; Jobe 1977, *Entomol. Gaz.* 28:8). Interpretations of this behavior have been speculative generalizations. Personal observations have revealed a third—also minor—function of the lepidopteran proboscis.

A female *Atalopedes campestris* (Boisduval) (Hesperiidae) was found floating with fluttering wings on the water surface of a wading pool in a residential backyard in Austin, Travis Co., Texas. The skipper did not appear to be severely injured, probably due to a relatively short period of partial submergence. Nevertheless, the scales were quite wet.

Subsequent observation of this individual revealed that it was rapidly probing the scaly covering of the anterior part of its body by continued manipulation of its proboscis. Most of the probing involved ventral and lateral scales of the thorax. A definite color-lightening effect was observed. This change in coloration would indicate a reduction in the amount of water which had a plastering effect upon the scales.

Decrease in amounts of water present among the scales could result from two effects of probing by the proboscis. Simple separation of adjacent matted scales by mechanical movement of the proboscis would increase evaporation rates because of an increase in scale surface area exposed to air. Also, water could be and probably was being physically removed by suction via the proboscis.

The primary behavioral regime enlisted in this task would involve an activity related to previous function—suction action of the proboscis. Therefore, physical removal of water should be regarded as the initial function upon which natural selection acted. Enhancement of evaporation rate by scale separation initially was an ancillary result of this behavior. Such enhancement could be further increased by selection favoring rapid random movements as opposed to sucking up water at one spot and relying on capillary pressure to maintain a continuous film of water.

Although this behavior was observed to function to remove water from scales following partial immersion in water, it could also function to remove moisture from rain (dew?) on butterflies roosting in exposed sites. Removal of water may be important for several reasons. Flying ability may be reduced if water is present in sufficient amounts to appreciably increase the weight of the insect. A matted water/scale film present on the body surface may interfere with spiracular inhalation or favor development of pathogenic populations. Even if most air were inhaled via abdominal spiracles, removal of thoracic surface water may decrease abdominal and wing surface water via capillary action.

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ERRATA

- p. 20, abstract, line 7, *W. ebenina* = *C. ebenina*
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p. 224, second paragraph, line 4, *E. mellinate* = *E. mellinata*
Vol. 3 Contents on back cover, fourth line from bottom, Mark Fink = Mark Finke
(The Editor regrets these errors)

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JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



4 June 1979

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Cover illustration: Third instar larva of *Limenitis archippus* Cramer (Nymphalidae) preparing to enter winter diapause. The larva is resting on the lip of its hibernaculum constructed from the basal portion of a chewed tubular willow leaf (*Salix babylonica* Linnaeus) covered with silk. In the autumn such larvae begin facultative diapause in response to decreasing day-length. Original drawing by Mr. George C. Ford, Jr., Graphics Illustrator, Department of Biological Sciences, University of Maryland Baltimore County, 5401 Wilkens Avenue, Catonsville, Maryland 21228.

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 33

1979

Number 1

Journal of the Lepidopterists' Society
33(1), 1979, 1-5

PAITITIA NEGLECTA, GEN. N., SP. N. FROM PERÚ (NYMPHALIDAE: ITHOMIINAE)¹

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ABSTRACT. *Paititia neglecta*, gen. n., sp. n., from Perú, San Martín, Juanjui, is described herein. This monotypic genus is considered to be the most primitive member of the tribe Mechanitini of the Ithomiinae.

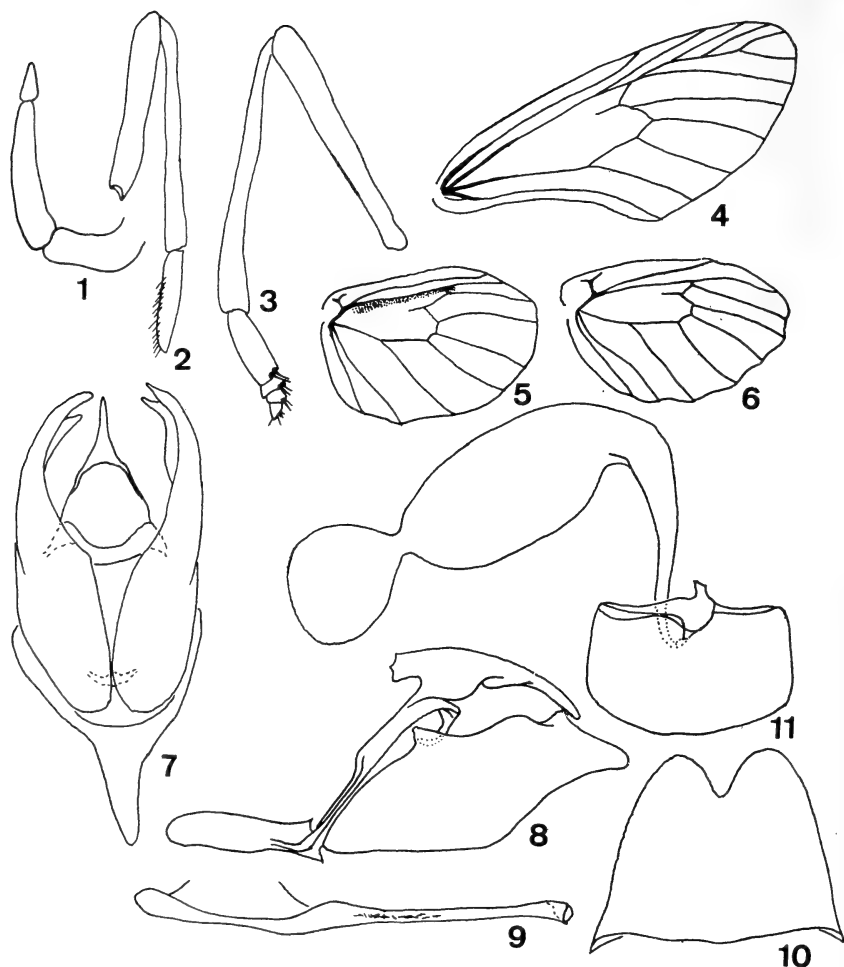
Two specimens, representing a new genus and species of Ithomiinae, lay unnoticed for almost 50 years in the collections of the British Museum (Natural History), London, and the American Museum of Natural History, New York. The BMNH female was included among a series of unidentified *Methona* examples in the Rothschild collection, while the AMNH male had been identified (and labelled) as "*Xanthocleis ino*" by the late R. M. Fox. The third known specimen (a male) was presented to the "Javier Prado" Museum in 1976 by the collector, Mr. José M. Schunke.

***Paititia* Lamas, new genus**

External diagnostic characters. Large Mechanitini (Fox, 1956), very similar in size and color pattern to *Thyridia psidii* ssp. and *Methona* spp. May be distinguished from *Thyridia psidii* (Linnaeus) by the absence of small red dots on base of forewing above, and the presence of two separate, white spots on cell Sc-R₁-R_s of hindwing below. *Paititia* may be separated from *Methona* spp. by the long hair patch extending beyond the discal cell apex of the male hindwing above, which in the latter is restricted to the basal half or two-thirds of that cell.

In Fox's key (1940), the males of *Paititia* will key out to *Xanthocleis* Boisduval (i.e., *Thyridia* Hübner), but may be readily differentiated by the characters given above. The females will key out to *Athesis* Doubleday; however, they can be easily distinguished by the wing shape and

¹ The present paper forms part of a D.Sc. dissertation submitted to the Departamento de Zoologia, Instituto de biociências, Universidade de São Paulo, São Paulo, Brasil (Lamas, 1973). As a condensed version of that thesis will not be published in the near future, I have decided to make available the new genus and species of Ithomiinae described therein.



FIGS. 1-11. *Paititia neglecta*, gen. n., sp. n.: 1, palpus; 2, male foreleg; 3, female foreleg; 4, male forewing; 5, male hindwing; 6, female hindwing; 7, male genitalia, ventral view; 8, male genitalia, lateral view; 9, penis; 10, male eighth tergite, dorsal view; 11, female genitalia, ventral view.

color pattern (wings long and narrow, with yellowish transparent areas in *Paititia*, short and wide, with reddish-brown translucent areas in *Athesis*).

Palpi (Fig. 1). Basal segment curved, adpressed to the head; second free, 1.5 times longer than the basal; apical fusiform, very small, one-fifth to one-eighth the length of the basal (longer in male).

Antennae. Club yellow, with approximately 15 segments, very slightly widened,

barely more so than the pedicel, which is black; as long as the forewing discal cell, that is, slightly longer than one-half the forewing length.

Male forelegs (Fig. 2). Reduced; femur plus trochanter as long as the stout articulate coxa; tibia one-fourth longer than femur; tarsus two-fifths the length of the tibia, with slender spines on ventral side.

Female forelegs (Fig. 3). Reduced, coxa articulate; femur as long as coxa; tibia equal to femur plus trochanter; tarsus with 4 apparent segments, two-fifths the length of the tibia; basal segment twice the length of the remainder; second and third short, apical consisting of the fourth and fifth fused; first segment with two pairs of spurs, the outer ones slightly longer; second and third segments with a pair of spurs each; second, third and apical segments with trichoid sensillae.

Venation (Figs. 4-6). Sc and R_1 on forewing of both sexes running parallel, without anastomosing, Sc ending shortly beyond discal cell apex; R_1 arising from cell, base of R_2 anastomosed to R_{3+4+5} , well beyond cell apex; $rs-m_1$ absent or very short, straight; m_1-m_2 long, angular, long Rc arising from angle; m_2-m_3 also long, straight.

Male hindwing with bifid hum, both arms well developed; Sc and R separate at base, Sc ending beyond discal cell apex; $rs-m_1$ straight, slightly more than half as long as m_2-m_3 ; m_1-m_2 angular, both arms straight and of equal length, Rc on angle; m_2-m_3 straight. Hair patch complete, running along upper portion of discal cell, behind radial vein, from base to beyond cell apex.

Female hindwing. Similar to male, except that Sc ends scarcely beyond cell apex; $rs-m_1$ very short, less than one-third the length of m_2-m_3 ; no hair patch.

Male genitalia (Figs. 7-10). Eighth tergite with two short and distally widened lateral lobes, without sclerotized claws; saccus short, one-half as long as the valva; tegumen hood-like, not separated by a suture from uncus; uncus stout, posterior area with a strong claw bent downwards; juxta V-shaped, poorly developed; appendices angulares not sclerotized; gnathos lightly developed, its arms being united below the tuba analis by means of a membrane only; valvae symmetrical, long, quite wide, bearing two claw-like appendices on their caudal ends, upper claw shorter and stronger than lower; penis long, slender, curved between the anterior and middle thirds; foramen penis very long, one-third of the total length; gonoporus flared, terminal; vesica with cornuti.

Female genitalia (Fig. 11). Vaginal plate irregular, funnel-shaped, with a lateral aliform process on left side; ostium bursae located left of longitudinal axis of abdomen; caudal end of ostium bursae strongly sclerotized and slightly bent left and downwards, remainder of ductus very long; bursa copulatrix with poorly developed signa and with a globular appendix bursae.

Type-species: *Paititia neglecta* Lamas, sp. n.

Etymology. The generic name is based on the Quechua word "Paititi," which refers to the fabulous kingdom of "El Dorado," so ardently sought by explorers and adventurers in South America, almost ever since the discovery of the New World. It should be treated as being of feminine gender.

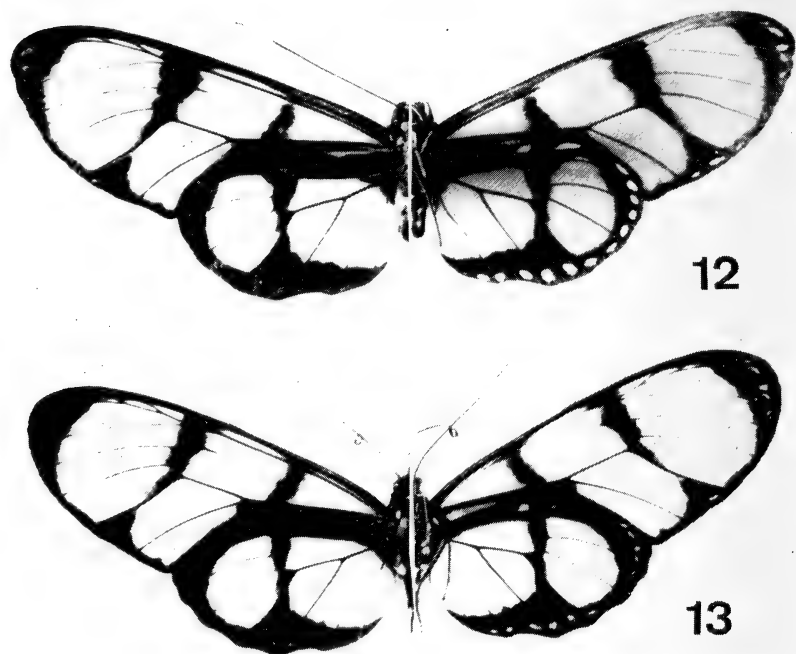
Paititia neglecta Lamas, new species

Male (Fig. 12). Wing margins and transverse bands black, transparent areas with a yellowish tinge. Hindwing below with two white spots on cell Sc + R_1-R_5 and a row of marginal double white spots on cells M_1-M_2 to Cu_2-2A . Humeral spot white, costal line pale yellow. Abdomen below, and all other body spots, white.

Female (Fig. 13). Similar to male, hindwing white, marginal spots smaller.

Types. HOLOTYPE ♀, Juanjui, San Martín, Perú; xi.34 (G. Klug), deposited in the British Museum (Natural History). One PARATYPE ♂, Achinamiza, San Martín, Perú; 14.i.26 (H. Bassler, station F6001); AMNH Acc. 33591, in the American Museum of Natural History, New York. One PARATYPE ♂, Iberia, Madre de Dios, Perú; 27.vi.75 (J. M. Schunke), in the Museo "Javier Prado," Lima.

Etymology. The specific name is the Latin word for "forgotten."



FIGS. 12-13. *Paititia neglecta*, gen. n., sp. n.: 12, paratype male, Achinamiza; 13, holotype female. Dorsal left, ventral right.

DISCUSSION

Relationships

Paititia is considered to be the most primitive member of the tribe Mechanitini (Lamas, 1973). It indeed seems to represent a link between the Tithoreini and Mechanitini.

Paititia neglecta resembles members of the genus *Olyras* Doubleday (cf. Fox, 1940, 1956), in the shape of the male forelegs, wing venation and genitalia, and even the presence of the white spots on the hindwing cell $Sc + R_1-R_s$ below (present in most forms of *Olyras*). However, *Olyras* differs by the divided hair patch and by the valvae having only one short claw-like process, the females being even more different.

Paititia is very close to *Thyridia* Hübner (= *Xanthocleis* Boisduval), both having almost identical venation, but I believe the differences presented by the male and female genitalia and foretarsi are enough to separate them.

Natural history

Nothing is known about the life-habits of *Paititia neglecta*. Two of the localities where it has been found (Juanjui and Iberia) are characterized by rather dry tropical forest. This may represent an example of a primitive species which has been displaced to marginal habitats by a more modern and aggressive species, as seems to be the case with *Melinaea mnasias* (Brown, 1977).

ACKNOWLEDGMENTS

Research for the present paper was mainly financed by grants "Biológicas 70/671" and "72/849" of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Brasil. I acknowledge with special thanks the help and hospitality of Mr. R. I. Vane-Wright (British Museum [Natural History]), Dr. F. H. Rindge (American Museum of Natural History, New York), and the advice of Drs. P. E. Vanzolini and N. Papavero (Museu de Zoologia da USP, São Paulo) and K. S. Brown, Jr. (Universidade Estadual de Campinas, São Paulo). I am deeply obliged to Mr. J. M. Schunke for having obtained the third known specimen of *Paititia neglecta* for the "Javier Prado" collections.

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EXPERIMENTAL HYBRIDIZATION BETWEEN *PHYCIODES* *THAROS* AND *P. BATESII* (NYMPHALIDAE)

CHARLES G. OLIVER¹

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ABSTRACT. F₁ hybrids and backcrosses were made between the nymphalid butterflies *Phyciodes tharos* and *P. batesii*. The two species differ in larval, pupal, and adult phenotypic appearance, ecology, and larval diapause response. Genetic incompatibility was shown by significant hybrid inviability, growth irregularities, and abnormal adult sex ratios and development times. The reciprocal F₁ hybrids differed greatly in their expression of incompatibility. Hybrid inviability is attributed to breakdowns in the genetic mechanisms controlling growth and development.

The relationship of *Phyciodes tharos* Drury to *P. batesii* Reakirt has been little understood despite the fact that they both occur in comparatively densely populated areas of the northeastern United States and have been known to be distinct for well over a century. This confusion appears to be due to two causes. First, *P. tharos* is common to abundant over the entire range of *P. batesii*. Since *P. batesii* occurs in widely separated, small populations, it is probably often overlooked due to its superficial resemblance to *P. tharos*. Second, the biology of *P. tharos* itself actually is poorly known. Rearing and hybridization studies now in progress in my laboratory indicate that "*P. tharos*" in the Northeast consists of two entities differing in larval and adult phenotypic appearance and voltinism and showing significant incompatibility when hybridized in the laboratory (Oliver, in prep.). The more southern entity, hereafter referred to as "Type A," occupies the Transition and Austral Life Zones, whereas the more northern "Type B" is the "*P. tharos*" of northern New England, northern New York State, and southern Canada. The phenotypic differences of Types A and B have resulted in Type B passing as *P. batesii* in many collections, although it resembles *P. batesii* little more than does Type A.

Phyciodes batesii is very local in the Northeast. It appears to be restricted to dry sites, often of the barrens type. The Onondaga Co., New York, population used in these experiments occurs on dry limestone ledges. In the Appalachians of Pennsylvania and West Virginia, the localities I have investigated are for the most part shale barrens or rocky riparian slopes. One of the best known localities, along the banks of the Ottawa River near Aylmer, Quebec, was described by McDunnough (1920) as the "lower dry slopes of a small ridge." Both Types A and B of *P. tharos* occur in a wide variety of habitats, including those of *P. batesii*.

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Phyciodes batesii flies in early June in West Virginia and southwestern Pennsylvania and in mid June in central New York State. In West Virginia and southern Pennsylvania this is between the rather discrete first and second broods of *P. tharos* Type A, which has a total of three to four broods. In Onondaga Co., New York, however, *P. batesii* and *P. tharos* Type B fly together. Thus, the observation of Forbes (1960) that broods of *P. tharos* and *P. batesii* alternate at any given locality seems to apply only to the southern portion of the range of *P. batesii*.

The life history of *P. batesii* was described and figured by McDunnough (1920). The larva and pupa differ in a number of characters from those of *P. tharos* (Table 1) and are much more like those of *P. campestris*, which were figured by Comstock (1930) and compared briefly to *P. tharos* in another paper of mine (Oliver, 1978). First and second instar larvae of both *P. campestris* and *P. batesii* live communally within a loose web spun over the feeding area on the foodplant. *P. tharos* has a similar communal behavior, but no web is spun.

McDunnough was able to obtain oviposition by *P. batesii* on "a species of *Aster* with heart-shaped leaves," found wild larvae on this plant, and successfully reared them through to adults. This *Aster* was probably *A. undulatus* L., which is very common in *P. batesii* habitats. Wild-caught *P. batesii* females from Onondaga Co., New York, refused to oviposit on *Aster undulatus* in the laboratory, but laid readily on *A. simplex* (Willd.) Burgess, a common foodplant of *P. tharos*. Newly-hatched larvae of both *Phyciodes* fed readily on *A. undulatus* when transferred to its leaves. Larvae of both species also accepted *A. laevis* L.

More than 200 unmated, laboratory-reared *P. batesii* adults were released shortly after eclosion during August into a western Pennsylvania old-field habitat containing abundant *Aster simplex* (but no *A. undulatus*). Several pairs were observed *in copulo* the next day. In early October a group of small larvae was recovered from a clump of *A. simplex* and reared through to normal adults the following spring, indicating that *P. batesii* may choose more than one species of *Aster* as natural foodplants.

In the northern Midwest (e.g., Michigan and Wisconsin) *P. batesii* has a somewhat different biology. Colonies occur in moist areas, and there is sometimes a partial second brood (Nielsen, *in litt.*). Populations in the Northeast seem to be strictly univoltine. Midwestern *P. batesii* differ slightly in appearance from those in the Northeast and may possibly represent a separate entity.

PROCEDURE

Stock of *P. batesii* used in these experiments was derived from four wild-inseminated females collected 11 June 1976, in Syracuse, Onondaga

TABLE 1. Comparison of phenotypic appearance of *P. tharos*, *P. batesii*, and their F_1 hybrids.

Character	<i>P. tharos</i>	<i>P. batesii</i>	F_1 hybrids
I. Mature larva			
a. Body ground color	Dark chocolate brown	Brown w. pinkish tinge	Brown w. pinkish tinge
b. Tubercle color	Gray or dark brown	Light pinkish brown	Light pinkish brown
c. Tubercle tip color	White	Concolorous light brown	White
d. Dorsal light stripes	Faint, broken	Compar. heavy, even	Intermediate
e. White patches, head capsule	Extensive dorsally and laterally	Gr. restricted dorsally and laterally	Intermediate
f. Setal coloration	Light brown	Chocolate brown	Chocolate brown
II. Pupa			
Overall appearance	Much more angular in outline; dorsal projections relatively pronounced	Much more rounded in outline; dorsal projections almost absent	Intermediate
III. Adult			
A. Dorsal			
1. Black pattern expression	Relatively light; large open orange areas	Very heavy; wing area predominantly black	Very variable; ♂ ♂ intermediate, ♀ ♀ exceed parental variation
2. Wing fringes color	Checkered light gray and dark gray	Checkered white and dark gray	Intermediate
3. Body vestiture color	W. large proportion of tawny hairs	Almost all gray	Almost all gray
B. Ventral			
1. Antennal club color	Brown	Dark gray	Brown
2. FW light ground color	Dark orange	Pale orange to straw yellow	Intermediate
3. FW median dark spots	Isolated, not forming band	Tend to form continuous band	Intermediate
4. Rel. sizes, lowest median vs. subapical black patches	Subapical > median	Median > subapical	Median \geq subapical
5. HW ground color	Dark straw yellow	Very pale straw yellow	Intermediate
6. Small submarginal dark spots (♂ ♂ only)	Brown w. or w/o pinpoint black center	Black	Black or brown w. pinpoint black center
7. Anal dark patch	Large, often clouding silver crescent	Usually only silver crescent present	Variable, usually faint or absent

Co., N.Y. Stock of *P. tharos* Type A was derived from four females taken 10 June 1976, in Acme, Westmoreland Co., Pennsylvania, and of Type B from two females taken 11 June 1976, at the Onondaga Co., N.Y. locality. Cultures were maintained at 15 to 28°C and separated into controlled photoperiod (18 h light/24 h or 24 h light/24 h) and natural photoperiod (for Fayette Co., Pa., latitude 40°N) groups. Artificial lighting after sunset was provided by a 100-watt incandescent bulb at a distance of 1 to 2 meters.

Matings were made by the hand-pairing method (Clarke, 1952). Fecundated females were provided with cut sprigs of *Aster simplex* for oviposition. Eggs were left *in situ* until hatching and the aster sprigs kept fresh in water. Larvae were reared on cut sprigs of *A. simplex* in water and housed in 10 × 20 cm glass cylinders.

The photoperiodically-regulated larval diapause in *Phyciodes* occurs at the beginning of the third instar. Diapausing larvae were removed from active cultures, placed in groups in 90 mm plastic petri dishes, sealed in airtight containers, and stored in a domestic refrigerator at 0 to 2°C until April or May of the following year. Upon removal from the diapause containers all larvae were maintained at 15 to 28°C and 18 h light/24 h until pupation, at which time they were transferred to natural light conditions.

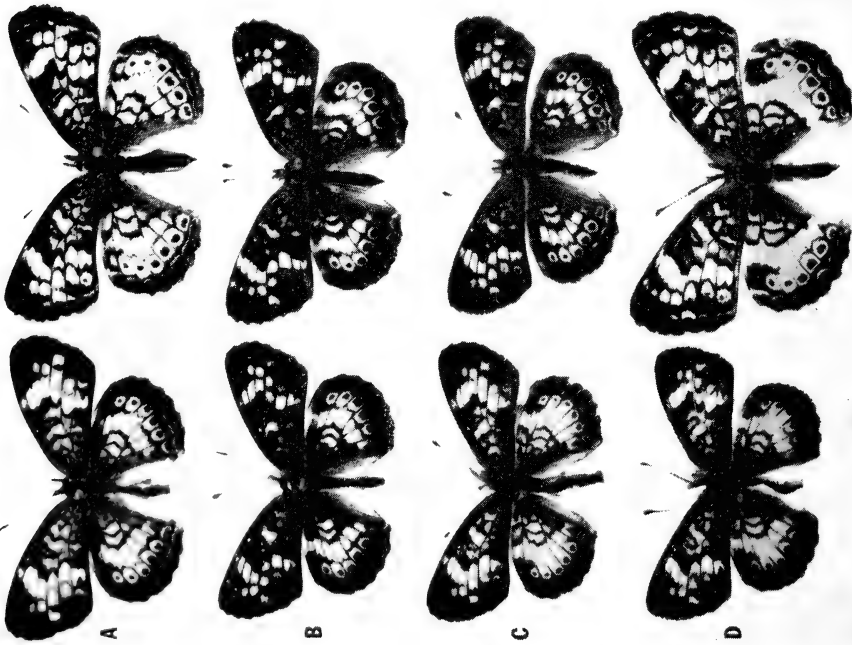
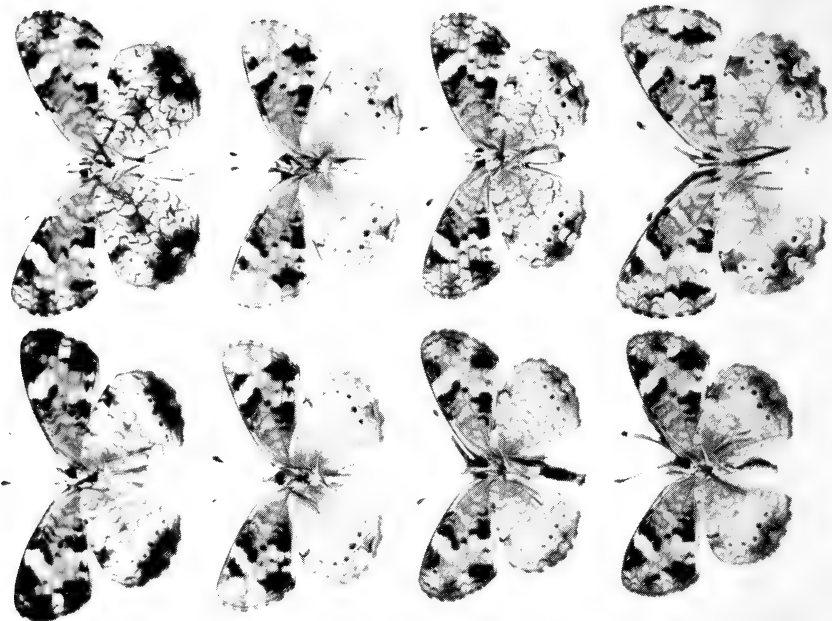
F₁ progeny of wild-collected females was used for the hybrid pairings and as parental-type stock for backcrosses; no stock used was inbred. Observations were made on parental population and F₁ hybrid phenotypic appearance, interspecific courtship behavior, development periods and adult eclosion patterns, fertility, adult sex ratios, embryonic, pupal, and adult viability, and on backcross embryonic viability. Controls were reared concurrently at all times for comparison with experimental broods.

Data on egg fertility, viability, and sex ratios were treated statistically using the Wilcoxon Two-sample Test. Adult fertility was measured by a count of the number of visibly developing eggs divided by the total number of eggs laid after a single mating. Development periods from hatching of the egg to eclosion of the adult were estimated by calculating the 99% confidence intervals for the medians of the distributions (Owen, 1962). Distributions of development times within broods or series of broods were represented by adult eclosion curves, graphs of the number of adults eclosing from pupae each day.

RESULTS

Interspecific courtship behavior

Courtship in both *P. tharos* and *P. batesii* is apparently dependent on a variety of stimuli. The presence of a butterfly of appropriate coloration



and size elicits approach by males. If the approached individual does not leave or, in the case of conspecific males, show aggressive behavior, an attempt at copulation will be made. Females which do not wish to copulate avoid the male's probing genitalia by dorsal or lateral movement of the abdomen. Males of both *P. tharos* and *P. batesii* showed the courtship approach response when presented with females of the other species. After an initial response, however, males of neither species attempted to copulate. Some stimulus, perhaps olfactory, appeared to terminate courtship.

Phenotypic appearance

Differences in phenotypic appearance of the fifth instar larvae, pupae, and adults of the parental species and F_1 hybrids are summarized in Table 1. Typical specimens of adults are shown in Fig. 1. There was wide variation in adult phenotypic appearance among the F_1 hybrid broods.

The artificial illumination levels used to extend daily photophase in these experiments eliminated facultative diapause in *P. tharos* (see below), but the induction of the naturally-occurring adult seasonal forms was little affected. The photoperiodic regulation of polyphenism in *P. tharos* has been described in a previous paper (Oliver, 1976). Univoltine *P. batesii* do not, of course, show natural seasonal polyphenism. Under the artificial long-day laboratory conditions described above, however, non-diapausing larvae produced late summer and early fall adults which had significantly heavier expression of the dark wing pattern elements on both the ventral and dorsal sides. This artificially induced form did not differ from the naturally occurring phenotype as the seasonal forms of *P. tharos* differ from each other. F_1 hybrid adults emerging in September and October showed some expression of the short photophase phenotype but not to as great an extent as did the *P. tharos* controls.

Phyciodes tharos and *P. batesii* differ in the length of time required for full embryonic development. Eggs of *P. tharos* kept at natural outdoor temperatures during early August hatched after 6 days. Those of *P. batesii* required an additional day or day and a half. The hatching times of the F_1 hybrids varied within broods from 6 to 7½ days.

Fertility, viability, and sex ratio

Egg fertility and embryonic viability of control broods was very high (Table 2). Fertilizability of eggs was slightly reduced in the F_1 hybrid

←

FIG. 1. Parental-type and F_1 hybrid adults: Row A—*P. tharos*; B—*P. batesii*; C— F_1 hybrids *P. batesii* ♀ × *P. tharos* ♂; D— F_1 hybrids *P. tharos* ♀ × *P. batesii* ♂. Specimens show, left to right, male dorsal, female dorsal, male ventral, female ventral.

TABLE 2. Mean egg fertility (fertile/laid) and embryonic viability (hatched/fertile) of *P. tharos* (*th*), *P. batesii* (*ba*), *F*₁ hybrid, and backcross broods. Second decimal value indicates standard deviation. Tests of significance refer to comparison of hybrids with controls.

Mating	No. of broods	No. of eggs	Fertile/laid	Hatched/fertile
Parental controls				
<i>th</i> : Acme, Pa.	9	4405	0.987 ± .027	0.995 ± .022
<i>th</i> : Syracuse, N.Y.	6	4370	0.987 ± .011	0.998 ± .032
<i>ba</i> : Syracuse, N.Y.	5	2533	0.938 ± .099	0.990 ± .010
<i>F</i> ₁ hybrids				
NY <i>th</i> ♀ × <i>ba</i> ♂	2	1202	0.770 ± .219 (N.S.)	0.939 ± .058 (N.S.)
<i>ba</i> ♀ × NY <i>th</i> ♂	10	4792	0.917 ± .089 (P = .05)	0.516 ± .233 (P < .001)
<i>ba</i> ♀ × Pa <i>th</i> ♂	3	977	0.815 ± .249 (N.S.)	0.173 ± .218 (P < .001)
Backcrosses				
NY <i>th</i> ♀ × (NY <i>th</i> ♀ × <i>ba</i> ♂) ♂	9	2754	0.806 ± .252 (P < .10)	0.494 ± .174 (P < .001)
(<i>ba</i> ♀ × NY <i>th</i> ♂) ♀ × NY <i>th</i> ♂	6	1209	0.929 ± .067 (P < .025)	0.154 ± .210 (P < .001)
<i>ba</i> ♀ × (NY <i>th</i> ♀ × <i>ba</i> ♂) ♂	3	507	0.498 ± .366 (P < .025)	0.054 ± .052 (P = .005)
(NY <i>th</i> ♀ × <i>ba</i> ♂) ♀ × NY <i>th</i> ♂	3	2099	0.980 ± .015 (N.S.)	0.978 ± .002 (N.S.)
NY <i>th</i> ♀ × (<i>ba</i> ♀ × NY <i>th</i> ♂) ♂	2	817	0.942 ± .025 (P = .10)	0.888 ± .098 (P = .05)

crosses. Embryonic viability was heavily depressed in the *P. batesii* ♀ × *P. tharos* ♂ F₁ hybrid series, but not demonstrably affected in the reciprocal cross. Embryonic viability of the *P. batesii* ♀ × N.Y. *P. tharos* ♂ F₁ hybrid series may differ from that of the *P. batesii* ♀ × Pa. *P. tharos* ♂ series ($P = .10$). Backcross embryonic viability was drastically reduced. Embryonic viability of both F₁ hybrids and backcrosses showed great variability among broods (Table 2).

Post-larval viability (i.e. during pupation and eclosion and as pupae) was greatly reduced in the *P. batesii* ♀ × *P. tharos* ♂ F₁ hybrids and to a lesser extent in the reciprocal cross. The decrease in viability was almost entirely during the pupal stage (Table 3).

Adult sex ratios of the *P. batesii* ♀ × *P. tharos* ♂ F₁ hybrid series did not differ significantly from those of the parental broods (Table 3). In the two *P. tharos* ♀ × *P. batesii* ♂ broods, however, female adults were entirely absent (Brood 76-43) or greatly reduced in numbers (to 16.07% in Brood 76-42).

Structural abnormalities

Structural abnormalities involving segmental irregularities were relatively common in the *P. batesii* ♀ × *P. tharos* ♂ hybrid broods, though absent in the parental controls and reciprocal crosses. Between 0 and 15% (no exact counts made) of the larvae of each hybrid brood showed a lack of development of one side of an abdominal segment. The affected segment half was both narrower and shorter than the corresponding half, often lacked a tubercle, and resulted in the larval abdomen abruptly bending to one side. Two larvae were segregated and observed throughout development. In these, the segmental irregularity persisted through the pupa and into the adult (Fig. 2). Both larvae produced apparently otherwise normal male adults.

F₁ hybrid males from the cross *P. batesii* ♀ × *P. tharos* ♂ had disproportionately large, flaccid abdomens (Fig. 1). The genitalia of many individuals were apparently permanently extruded, and hand-pairings using any males were very difficult. No males would mate naturally in cages.

Voltinism

The *P. tharos* Type A population culture from Westmoreland Co., Pa., showed no incidence of larval diapause when reared on a photoperiod regime of 18 h light/24 h or under natural photoperiod conditions during June and July. Broods reared under natural photoperiod during August and September showed a significant incidence of diapause (Table 4). The *P. tharos* Type B population culture from Onondaga Co., N.Y., on the

TABLE 3. Incidence (percentages) of inviability during and after pupation of New York State *P. tharos* (*th*), *P. batesii* (*ba*), and their F_1 hybrids and backcrosses. Tests of significance refer to comparisons of hybrids with controls.

Species/Cross	No. of broods	Dead prepupae	Dead pupae	Total no. enclosing	Sex ratio (mean % ♂)	Eclosion incomplete	Crippled adults	Viable adults
<i>th</i> controls	6	0.72	4.59	1515	49.88	0.37	0.45	93.48
<i>ba</i> controls	4	1.66	8.32	686	45.87	2.56	2.21	85.25
<i>ba</i> ♀ × <i>th</i> ♂	8	1.60 (N.S.)	36.27 $P < .001$	393	47.10 (N.S.)	1.57 (N.S.)	2.35 (N.S.)	57.14 ($P < .001$)
<i>th</i> ♀ × <i>ba</i> ♂	2	0.20 (N.S.)	14.90 ($P < .005$)	264	91.24 ($P < .005$)	0.78 (N.S.)	1.61 (N.S.)	82.51 ($P = .10$)
(<i>th</i> ♀ × <i>ba</i> ♂) ♀ × <i>th</i> ♂	3	1.61 (N.S.)	7.59 (N.S.)	485	46.27 (N.S.)	0.81 (N.S.)	1.66 (N.S.)	88.33 (N.S.)
<i>th</i> ♀ × (<i>ba</i> ♀ × <i>th</i> ♂) ♂	2	0.00 (N.S.)	3.22 (N.S.)	279	31.82 (N.S.)	0.54 (N.S.)	5.74 (N.S.)	90.50 (N.S.)

TABLE 4. Mean incidence of larval diapause and diapause survival rate (percentages) of *P. tharos* (*th*), *P. batesii* (*ba*), and their F_1 hybrid *P. tharos* ♀ × *P. batesii* ♂. Homogeneous broods have combined.

Species/origin	Date hatched	Photophase exposure	No. of broods	Total no. of larvae	Diapause incidence	Survival rate
<i>th</i> (Pa.)	16-23 Jun	natural	4	928	0.00	—
<i>th</i> (Pa.)	29-30 Jul	natural	2	343	15.92	1.00
<i>th</i> (NY)	19-26 Jun	natural	2	1439	21.40	32.60
<i>th</i> (NY)	13 Aug	18 h 1/24 h	4	573	0.00	—
<i>ba</i>	24 Jun-2 Jul	natural	2	510	100.00	67.98
<i>ba</i>	21-25 Jun	24 h 1/24 h	4	1208	39.26	21.68
<i>ba</i>	22-28 Aug	18 h 1/24 h	1	347	35.73	67.21
<i>th</i> ♀ × <i>ba</i> ♂	15-18 Aug	18 h 1/24 h	2	394	19.34	28.92



FIG. 2. *P. batesii* ♀ × *P. tharos* ♂ F_1 hybrid male adult showing asymmetrical development of abdominal segment (arrow).

TABLE 5. Development times in days from hatching of egg until eclosion of adult for non-diapausing *P. tharos* and *P. batesii* control broods, F₁ hybrids, and backcrosses. Medians with 99% confidence. See text for rearing conditions.

Brood no.	Date hatched	N	Males Min-Max	Median	N	Females Min-Max	Median
<i>P. tharos</i> (New York)—Natural photophase							
76-8	19-26 June	177	32-53	34-36	134	33-52	38-39
76-9	19-23 Jun	216	32-50	34	190	32-41	36-37
<i>P. tharos</i> (New York)—18 h light/24 h							
76-38	13 Aug	84	33-44	36-37	95	37-54	42-44
76-40	13 Aug	90	33-46	34-35	79	35-70	37-42
76-41	13 Aug	22	33-37	33-34	31	34-55	35-39
<i>P. batesii</i> —24 h light/24 h							
76-1	21-25 Jun	57	38-107	49-56	37	43-116	56-57
76-2	21-25 Jun	54	33-105	49-76	49	40-116	55-76
76-3	24-25 Jun	23	40-97	48-55	34	48-134	51-62
76-4	21-25 Jun	30	38-86	41-64	33	38-89	45-55
<i>P. batesii</i> ♀ × <i>P. tharos</i> ♂—18 h light/24 h							
76-5	13-15 Aug	11	40-61	42-59	8	35-54	35-54
76-6	14-18 Aug	61	39-73	49-53	65	33-56	41-46
76-7	15-18 Aug	15	42-77	51-67	27	34-65	42-47
76-8	20-21 Aug	4	51-58	51-58	5	39-56	39-56
76-10	15-21 Aug	40	45-74	51-54	37	35-55	39-42
76-11	22-29 Aug	28	44-65	49-57	19	38-57	41-48
76-13	22-23 Aug	3	59-69	—	1	50	—
77-1	4 Jun	4	44-84	—	9	34-40	34-40
77-2	30 May-2 Jun	24	40-60	42-47	18	36-48	36-40
77-3	3-5 Jun	10	34-41	34-41	6	32-36	—
<i>P. tharos</i> ♀ × <i>P. batesii</i> ♂—18 h light/24 h							
77-42	15-18 Aug	188	35-62	41-42			
77-43	16-17 Aug	40	36-58	38-40			
<i>(P. tharos</i> ♀ × <i>P. batesii</i> ♂) ♀ × <i>P. tharos</i> ♂—18 h light/24 h							
77-26	19-20 Jul	42	28-46	29-34	54	29-45	37-38
77-34	28-29 Jul	110	30-54	34-37	97	29-37	30-31
77-38	31 Jul-1 Aug	79	29-41	33-35	106	32-44	36-37
<i>P. tharos</i> ♀ × (<i>P. batesii</i> ♀ × <i>P. tharos</i> ♂) ♂—18 h light/24 h							
77-28	22-31 Jul				18	30-64	30-39
77-32	24-27 Jul	164	27-66	33-35	97	28-65	31-36

other hand, showed significant incidence of larval diapause when reared during June and July on natural photoperiod. This diapause response was entirely facultative, since there was a complete absence of diapause in larvae reared on 18 h light/24 h.

Phyciodes batesii reared on natural photoperiod during June and July showed a 100% incidence of larval diapause. Many of those reared on 24 h

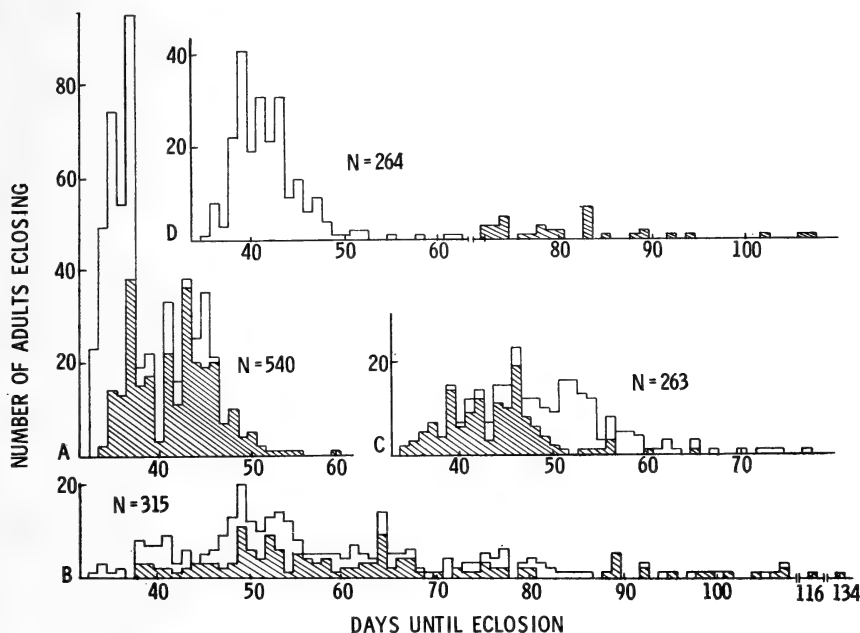


FIG. 3. Distributions of times required for development of New York State *P. tharos*, *P. batesii*, and F_1 hybrid broods from hatching of eggs until eclosion of adults. A—*P. tharos* hatching in late June, natural photophase, B—*P. batesii* hatching in late June, 24 h light/24 h; C— F_1 hybrid *P. batesii* ♀ × *P. tharos* ♂ hatching in early August, 18 h light/24 h; D— F_1 hybrid *P. tharos* ♀ × *P. batesii* ♂ hatching in early August, 18 h light/24 h.

light/24 h, however, developed without diapause, indicating that at least part of the culture was composed of facultatively diapausing individuals.

There was no incidence of diapause in F_1 hybrid larvae from the cross *P. batesii* ♀ × *P. tharos* ♂. The reciprocal hybrid, however, had an incidence of diapause intermediate between those of the parental species (Table 4). Survival of the F_1 hybrid larvae during diapause storage was normal compared with that of the parental species.

Development periods and eclosion patterns

The median development periods from hatching of the egg to eclosion of the adult were significantly longer for non-diapausing *P. batesii* than for concurrently reared non-diapausing *P. tharos* from New York State or Pennsylvania (Table 5). In addition, emergences were very scattered, producing a very different eclosion pattern from that of either population of *P. tharos* (Figs. 3A and B).

TABLE 6. Post-diapause development periods of *P. tharos*, *P. batesii*, and their F₁ hybrid *P. tharos* ♀ × *P. batesii* ♂. Medians with 99% confidence. All larvae removed from storage on same day (4 April 1977).

Brood no.	N	Males Min-Max	Median	N	Females Min-Max	Median
<i>P. tharos</i> (New York)						
76-8	105	41-49	43-44	153	42-56	49-50
<i>P. batesii</i>						
76-1	1	46	—	8	44-50	44-50
76-2	5	46-48	—	7	49-51	49-51
76-3	14	43-47	43-46	13	45-54	45-48
76-4	4	45-51	—	5	48-53	—
<i>P. tharos</i> ♀ × <i>P. batesii</i> ♂						
76-42	—			36	72-107	74-83

F₁ hybrids of the cross *P. batesii* ♀ × *P. tharos* ♂ showed eclosion patterns intermediate between *P. tharos* and *P. batesii*, but male development periods about the same as those of *P. batesii*. Females of this cross had shorter development periods and tended to emerge before the males, rather than the normal reverse (Fig. 3C).

Male development times of the cross *P. tharos* ♀ × *P. batesii* ♂ were significantly shorter, though not as short as those of concurrently reared *P. tharos*. The spread of eclosion times for male adults was much more like that of *P. tharos* than *P. batesii* (Fig. 3D). All *P. tharos* ♀ × *P. batesii* ♂ F₁ adults emerging without diapause were males; all those emerging after diapause, females. Resumption of feeding after diapause of these larvae was much delayed after removal from cold storage, and growth was much slower than that of the parental controls (Table 6).

DISCUSSION

It is clear from the results that *P. tharos* and *P. batesii* are well-differentiated species. There are marked differences in phenotypic appearance, voltinism, development rate, and ecology. The adults show strong behavioral isolating mechanisms during courtship in the laboratory. The heavy reduction in F₁ hybrid viability and fertility and in backcross embryonic viability indicates a high degree of genetic incompatibility between the species.

Phyciodes tharos and *P. batesii* appear to have achieved rather similar phenotypes (compared to *P. tharos* and *P. campestris*, for example) by somewhat different genetic means. This is attested to by the wide range of phenotypic variation in the F₁ hybrid adults and is especially marked in F₁ females from the cross *P. batesii* ♀ × *P. tharos* ♂. Expression of the

dorsal dark pattern elements ranges from as dark or darker than *P. batesii* to almost as light as *P. tharos* (Fig. 1). This indicates that the two species look more alike than they actually are.

I have discussed at length in another paper (Oliver, in press) the genetic basis of incompatibility effects involved in hybrid breakdown and surveyed the literature on viability of butterfly hybrids. The hybrid incompatibility shown between *P. tharos* and *P. batesii* may involve differences in the genetic control of hormones that direct growth and development. Disruption of normal hormonal control leads to formation of inviable embryos, abnormal tissue differentiation patterns, lessened fertility, lowered ability to pass from one life cycle stage to another, and abnormal development rates.

In general the genetic incompatibility between *P. tharos* and *P. batesii* is fairly similar to that shown between *P. tharos* and *P. campestris montana* Behr (Oliver, 1978). Both sets of F_1 hybrids have similar adult eclosion patterns. However, embryonic viability is reduced much more in the series *P. tharos* \times *P. batesii* than in *P. tharos* \times *P. campestris*. On the other hand, there is a much greater deficiency of F_1 hybrid females in the series *P. tharos* \times *P. campestris* than in *P. tharos* \times *P. batesii*. These differences and those in ecology, voltinism, and so on indicate that *P. batesii* and *P. c. montana* are physiologically quite distinct, and *P. batesii* probably should not be regarded as an eastern representative of *P. campestris*. *P. batesii* is more specialized than either of the other species. It appears to have evolved from multivoltine stock by lowering of the threshold of diapause induction to include all naturally encountered photoperiod conditions. Although capable of feeding on at least several species of *Aster*, it has become closely associated with (though perhaps not restricted to) a single species, *A. undulatus*, and seems in the Northeast to be found only in the rather narrow habitat range of this aster. Other butterflies have followed similar courses of evolution. *Pieris virginiensis* Edw., for example, has evolved univoltinism in apparently the same way (Shapiro, 1971; author's unpub. data) and has become restricted to the narrow habitat of its single foodplant, *Dentaria diphylla* Michx.

ACKNOWLEDGMENTS

I greatly appreciate the help of Mr. Edward Jennejohn, Manlius, New York, in obtaining laboratory stock of *Phyciodes batesii*. Mr. Joseph O. Brenneman provided invaluable photographic assistance.

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Journal of the Lepidopterists' Society
33(1), 1979, 20

TEMPORARY RANGE EXTENSION AND LARVAL FOODPLANT OF *DYNAMINE DYONIS* (NYMPHALIDAE) IN TEXAS

The northern normal limit of *Dynamine dyonis* Geyer in Texas is Cameron and Hidalgo counties. The occurrence of *D. dyonis* north of its usual range was noted on 27 July 1966, when I collected a tattered female on the Salado Creek, three miles southeast of the Northeast Preserve, a city park in San Antonio, Texas. The inundations of Hurricane Beulah in September 1967 produced lush vegetation in south Texas and may have caused the invasion of *D. dyonis* to extend as far north as Collin Co. (18 Sept. 1968, 2 ♂♂, leg. Edward Reid). Further evidence of this movement are records by the following collectors in other counties in 1968: Gonzales Co., Hidalgo Co. (both M. A. Rickard); Bell Co., San Patricio Co. (both R. O. and C. A. Kendall); Travis Co. (C. J. Durden); Brazos Co. (J. E. Hafernik). The last known record in 1968 was Bexar Co., 23 Nov., 1 ♀, leg. J. F. Doyle. The total number of *D. dyonis* taken by collectors in Texas from 27 July 1966 through 23 Nov. 1968 was 134 (68 ♂♂, 66 ♀♀). To my knowledge no populations remain in central or northern Texas.

On 5 May 1968, I observed a female *D. dyonis* as it fluttered about a trailing plant in a dry creek bed in the Northeast Preserve. The plant, *Tragia ramosa* Torrey (Euphorbiaceae), and the butterfly were caged and placed outdoors at my home in San Antonio, Texas. Twenty-four eggs were deposited that same day. The first larva emerged on 9 May. Only 6 larvae remained on 19 May because of cannibalism. Adults which emerged were: (31 May) 3 ♂♂, 1 ♀; (1 June) 1 ♂, 1 ♀.

Larvae were collected at the Northeast Preserve site in 1968 and reared on *T. ramosa*. These larvae were collected on 19 May and pupated 24 May. One adult (♂) emerged on 5 June. Larvae also were collected on 14 July and pupated between 17 and 18 July. Adults (1 ♂, 1 ♀) emerged on 23 and 25 July.

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NOMENCLATORIAL CHANGES IN EUCOSMINI (TORTRICIDAE)

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ABSTRACT. The genera *Kundrya*, *Norma*, and *Erinaea* are synonymized with *Rhopobota*. Female genitalia of *R. unipunctana*, *R. dietziana*, and *R. finitimana* are illustrated. *Griselda stagnana* and *G. myrtillana* are transferred to *Rhopobota*. *Epiblema separationis*, formerly a subspecies of *E. praesumptiosa*, is recognized as a species. Female genitalia of both species are illustrated. *Notocelia trimaculana*, *N. illotana*, *N. culminana*, and *N. purpurissatana* are distinguished from *Epiblema*.

Problems of identification, classification, and evolutionary relationships of the Olethreutinae have persisted in spite of the economic importance of many species in this subfamily. Heinrich's revision (1923) of the Eucosmini was based principally upon characteristics of wing venation and male genitalia. In recent years Bentinck and Diakonoff (1968), Diakonoff (1973), and Obratzsov (1958-1968), have recognized the value of the female genitalia in differentiating species as well as defining the genera. This paper presents modifications in the classification of selected Eucosmini genera and species as a result of the examination of the female genitalia and other characters.

Changes in *Rhopobota*

Rhopobota Lederer, 1859, Wien. Ent. Monat., 3: 366.

Type species: *Tortrix naevana* Huebner [1814-1817], by monotypy. Although Lederer considered *R. naevana* a senior synonym of *Tortrix unipunctana* Haworth [1811], *R. naevana* is now recognized as a junior subjective synonym of *R. unipunctana*.

Norma Heinrich, 1923, U.S. Natl. Mus. Bull. 123: 191. [New Synonymy.]

Type species: *Epinotia dietziana* Kearfott, 1907, by monotypy.

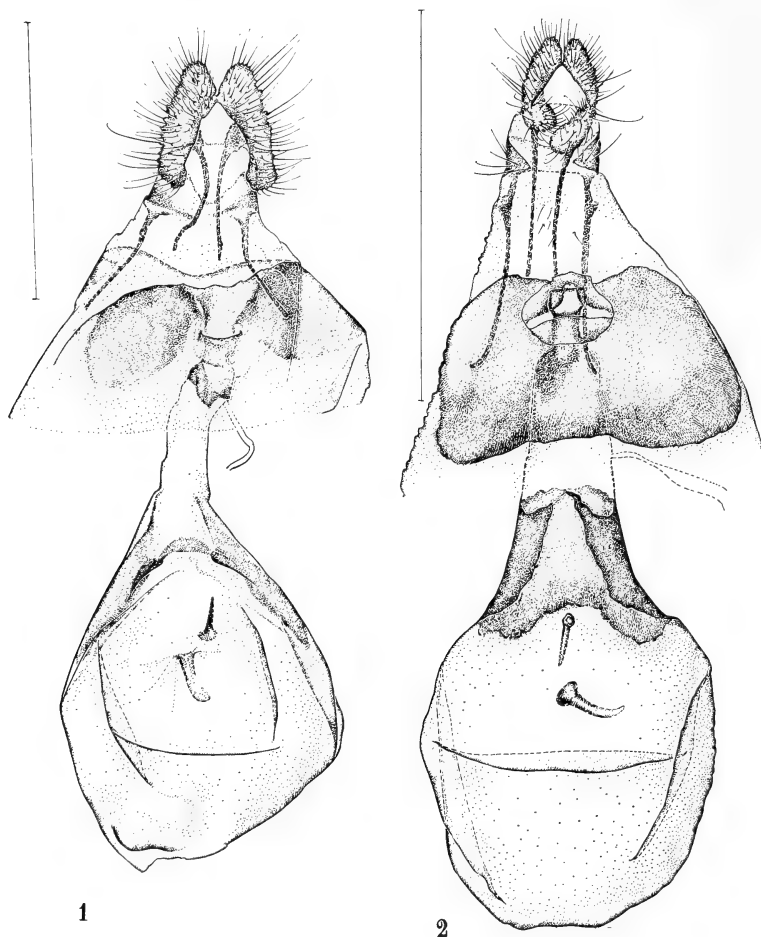
Kundrya Heinrich, 1923, U.S. Natl. Mus. Bull. 123: 192. [New Synonymy.]

Type species: *Kundrya finitimana* Heinrich, 1923, by monotypy.

Erinaea Meyrick, 1907, Journ. Bombay Nat. Hist. Soc., 18: 141. [New Synonymy.]

Type species: *Erinaea chlorantha* Meyrick, 1907, by monotypy; a junior subjective synonym of *Teras verditer* Hampson, 1891 (Diakonoff, 1950).

The genera *Norma* and *Kundrya* were considered by Heinrich to be close to *Rhopobota*. Heinrich distinguished *Kundrya* by a character of the forewing venation, R_4 and R_5 united. These two veins were described as stalked in *Rhopobota* and approximate in *Norma*. *Rhopobota* was separated from the first two on the basis of the porrect socii which are



FIGS. 1-2. Female genitalia including seventh abdominal segment: (1, left) *Rhopobota unipunctana* (Bellingham, Washington; USNM 17763); (2, right) *Rhopobota dietziana* (Ethel, Arkansas; R. L. Brown prep. 683). Scale line = 1 mm.

apically fused. Meyrick (1907) described *Erinaea* based upon a species from Ceylon, and did not indicate a relationship with *Rhopobota*.

Unique characters of the female genitalia of all the type species and a reassessment of previous distinctions provide the basis for synonymizing *Erinaea*, *Norma*, and *Kundrya* with *Rhopobota*. The most distinctive character is the sclerotization of the sides and base of the corpus bursae and distal area of the ductus bursae. A separate sclerotized band around the ductus bursae is located near the colliculum at the inception of the

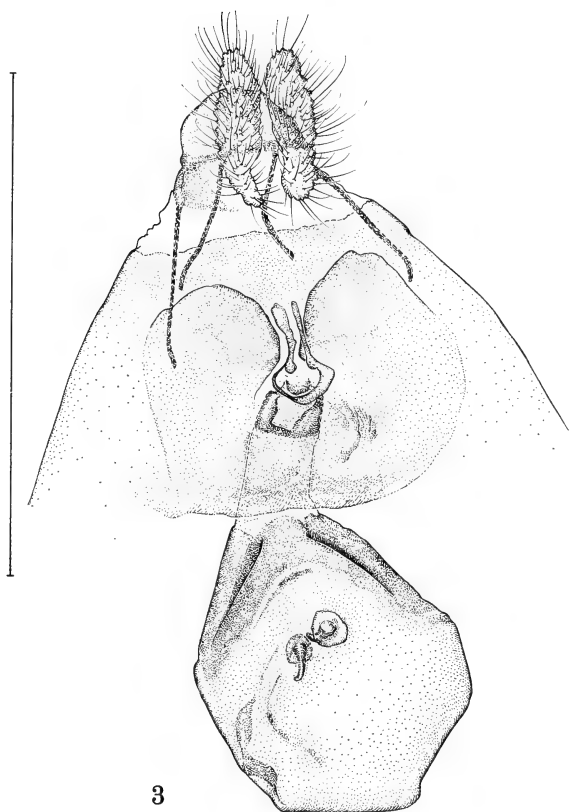


FIG. 3. Female genitalia including seventh abdominal segment of *Rhopobota finitimana* (Falls Church, Virginia; USNM 17762). Scale line = 1 mm.

ductus seminalis. The colliculum is sclerotized ventrally and extends beyond the lamella antevaginalis. Both the lamella antevaginalis and lamella postvaginalis are well developed and may be fused with or separate from the seventh sternite (Figs. 1, 2, 3; Clarke, 1958, pl. 169). These characteristics are also shared by the Asian species, *R. eclipticodes* (Meyrick) and *R. microrrhyncha* (Meyrick), as figured by Clarke (1958, pl. 170) and the Palearctic species, *R. ustomaculana* (Curtis), figured by Bentinck and Diakonoff (1968, fig. 189b, c).

The eighth tergite which surrounds the papillae anales possesses scales as well as simple setae in the three North American species, *dietziana*, *finitimana*, and *unipunctana*. Scales may be present or absent on the eighth tergite among the species of the related genera, *Epinotia*, *Ancyilis*, and *Chimoptesis*.

The male genitalia of *finitimana*, *dietziana*, and *unipunctana* are similar in having a bifurcate uncus with widely separated arms that are fingerlike and weakly sclerotized. The socii are long, porrect, and densely setose, separate in *finitimana* and *dietziana* and fused apically in *unipunctana*. The gnathos of *Rhopobota* is reduced and weakly sclerotized medially. The aedeagus is short in *finitimana*, longer in *dietziana* and *unipunctana*. The male of *chlorantha* has not been examined.

The condition of veins R_4 and R_5 in the forewing represents a transition from approximate in *dietziana* ($n = 17$) to stalked in *unipunctana* ($n = 37$) and united in *finitimana* ($n = 7$). The length of the stalk varies among the specimens of *unipunctana* examined. These veins are stalked in the type of *chlorantha*, as illustrated by Clarke (1958).

All three North American species of *Rhopobota* feed on *Ilex* (Aquifoliaceae). *R. unipunctana* also feeds on *Vaccinium* (Ericaceae) and is a pest of cranberry, *Vaccinium macrocarpon* Aiton (Heinrich, 1923). The larvae of *unipunctana* and *dietziana* were described by MacKay (1959) and were considered to be closely related.

Analysis of photographs and drawings of the genitalia (Bentinck and Diakonoff, 1968; Pierce and Metcalfe, 1922) provides evidence for synonymizing *Griselda stagnana* (Denis and Schiffermueller) and *G. myrtillana* (Westwood) with *Rhopobota*. Obraztsov (1945) included these two species in *Griselda* Heinrich, based on the presence of a costal fold in the forewing of the male. Powell (1964) provisionally retained these two in *Griselda* but indicated that they might not be congeneric with the type species, *G. radicana* (Walsingham), the sole North American species. The male and female genitalia of *G. radicana* are similar to those of *Epinotia hopkinsonana* (Kearfott) and *E. subviridis* Heinrich, all conifer feeders.

The presence of the costal fold in *stagnana* and *myrtillana* does not justify their separation from the other *Rhopobota* species which lack one. Secondary sexual characteristics, such as the costal fold of the male, are seldom of generic value, as is emphasized by Diakonoff (1973) in his study of the South Asiatic Olethreutini. My investigations of *Epinotia* also show the costal fold may be present or absent in closely related species.

Rhopobota stagnana ([Denis and Schiffermueller]). [New Combination.]

Tortrix stagnana [Denis and Schiffermueller], 1775, *Ankündigung eines Systematischen Werkes von den Schmetterlingen der Wienergegend*, p. 131.

Tortrix fractifasciana Haworth, [1811], *Lepidoptera Britannica*, 3: 466.

Rhopobota fractifasciana, Pierce and Metcalfe, 1922, *Genitalia British Tortricidae*, p. 75, pl. 26.

Griselda fractifasciana, Obraztsov, 1945, *Zeitschr. Wiener Entomol. Ges.*, 30: 33–34.

The female of *R. stagnana* has a corpus bursae with sclerotized sides.

The sterigma is similar in shape to that of *R. dietziana*, both lamella postvaginalis and antevaginalis are well developed. A sclerotized band around the ductus bursae is located near the colliculum. Scales are present on the eighth tergite, as shown in the specimen figured by Bentinck and Diakonoff (1968).

R. stagnana occurs in England and central Europe (Meyrick, 1895), and feeds on the flowers and seeds of *Scabiosa columbaria* L. (Dipsacaceae) in England (Ford, 1949).

Rhopobota myrtillana (Westwood). [New Combination.]

Sericoris myrtillana Westwood, In Humphreys and Westwood, 1845, British Moths, 2: 146, pl. 89, fig. 15.

Grapholitha vacciniana Zeller, 1846, Isis von Oken, p. 248.

Rhopobota vacciniana, Pierce and Metcalfe, 1922, Genitalia British Tortricidae, p. 75, pl. 26.

Griselda vacciniana, Obraztsov, 1945, Zeitschr. Wiener Entomol. Ges. 30: 34.

Griselda myrtillana, Bradley, 1959, Entomol. Gazette, 10: 72, pl. 11.

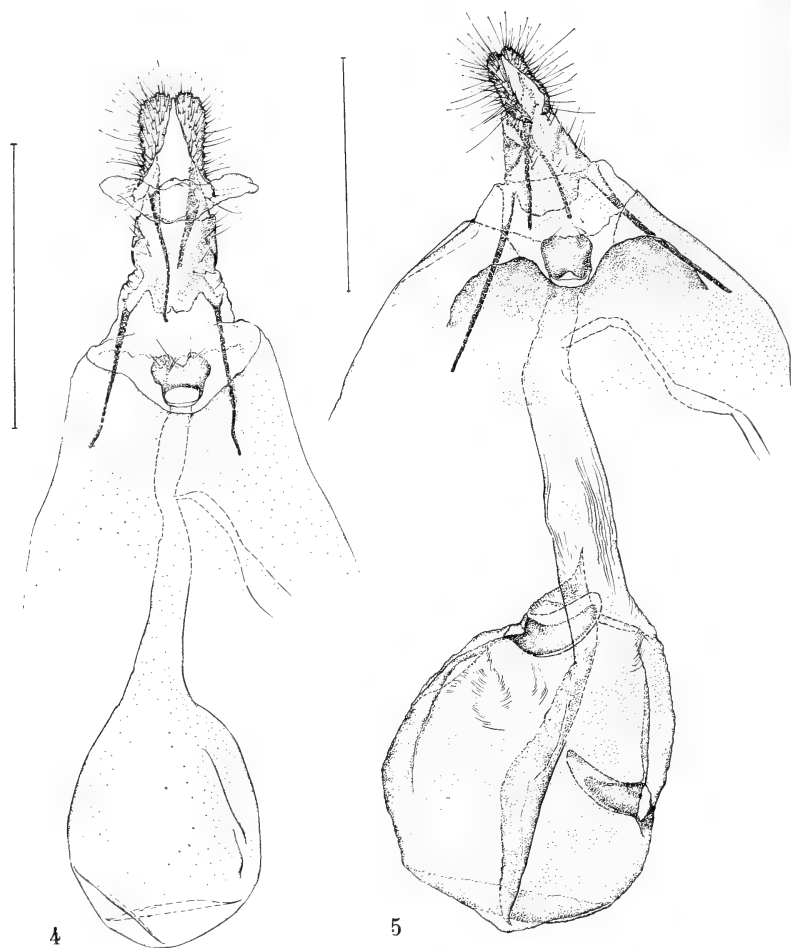
The female has a similar, although weaker, sclerotization of the corpus bursae than that described above. The sclerotized band around the ductus bursae is located near the colliculum. Both the lamella antevaginalis and postvaginalis appear well developed and separate from the seventh sternite. Scales on the eighth tergite probably are present, but are not evident in the figures. The male has a rudimentary clasper on the valva, similar to *R. unipunctana* and *ustomaculana*.

R. myrtillana occurs through north and central Europe and the British Isles. The larvae feed on *Vaccinium myrtillana* L. (Ericaceae) (Meyrick, 1895).

Changes in *Epiblema* Huebner

Epiblema separationis was described by Heinrich (1923) as a subspecies of *praesumptiosa* Heinrich but is raised to the species level in this paper. Heinrich characterized *separationis* by its smaller size, the absence of brown spots on the inner margin of the forewing ocellus and vein 1A, and the more rounded cucullus. *E. separationis* has a forewing expanse of 9–11 mm ($n = 10$); *praesumptiosa* has a forewing expanse of 14–17 mm ($n = 11$). However, the maculation of the forewing varies with the brown spots present or absent in each.

The most conspicuous differences are found in the female genitalia and seventh abdominal segment (Figs. 4, 5). *E. separationis* lacks signa on the corpus bursae, whereas *praesumptiosa* has two well developed signa. The papillae anales of *separationis* are widened apically but those of *praesumptiosa* are nearly uniformly wide. The lamella postvaginalis is more setose and emarginate posteriorly in *separationis*. The sclerotiza-



FIGS. 4-5. Female genitalia including seventh abdominal segment: (4, left) *Epibelema separationis* (San Benito, Texas; USNM 17735); (5, right) *Epibelema praesumptiosa* (Brownsville, Texas; USNM 17708). Scale line = 1 mm.

tion of sternite VII is relatively narrower and longer in *separationis* than in *praesumptiosa*. Both species lack sclerotization of the ductus bursae; however, the ductus bursae of *praesumptiosa* is distinct in being striate. Both species possess setae but lack scales on tergite VIII.

E. separationis possesses a tri-lobed eversible pouch ventrally, anterior to the papillae anales. This pouch can be everted by forcing alcohol with a syringe into the anterior opening of the seventh segment after it has been separated from the rest of the abdomen. The pouch appears to be glandular under high magnification.

The male genitalia of *separationis* differ from those of *praesumptiosa* in having shorter setae on the corona of the rounded cucullus, a smaller rudimentary clasper, and a truncate uncus. Male genitalia of both species have been figured by Heinrich (1923).

E. separationis appears to be closely related to *discretivana* (Heinrich). Both species lack signa and sclerotization of the ductus. *E. praesumptiosa* is thought to be most closely related to *numerosana* (Zeller), *grossbecki* Heinrich, *abruptana* (Walsingham), *deflexana* Heinrich, and *exacerbaticana* Heinrich. This species group shares the derived characteristic of long coronal setae on the cucullus. Sclerotization of the ductus is also lacking in this group. MacKay (1959) included *insidiosana* Heinrich in this group. However, *insidiosana* has short coronal setae on the cucullus and a sclerotized band around the ductus bursae.

The distribution of *separationis* within the United States is limited to southern Texas and Florida. The larvae, described by MacKay (1959), have been reared from galls of *Borrchia frutescens* (L.) (Compositae) in both localities. *E. praesumptiosa* is limited to southern Texas; the host plant has not been identified.

Four *Notocelia* species, *trimaculana* (Haworth), *illotana* (Walsingham), *culminana* (Walsingham), and *purpurissatana* (Heinrich), were included in *Epiblema* by Heinrich (1923). *N. suffusana*, a junior subjective synonym of *trimaculana*, was reassigned to *Notocelia* from *Epiblema* by Bentinck and Diakonoff (1968). MacKay (1959) described the external feeding larvae of *culminana* and *trimaculana* and considered them to be a separate genus but retained them in *Epiblema*.

Notocelia is distinguished from *Epiblema* by the presence of two non-deciduous cornuti at the apex of the aedeagus and a well-developed lamella antevaginalis of the female. The antevaginal plate is reflexed outward producing a projecting ostium. The ductus bursae of the female is lightly sclerotized from the ostium to the heavily sclerotized band at the inception of the ductus seminalis.

ACKNOWLEDGMENTS

I wish to acknowledge with my appreciation the following individuals and institutions who have provided specimens used in this study: D. R. Davis, U.S. National Museum of Natural History, Smithsonian Institution; J. G. Franclemont, Cornell University; Museum of Comparative Zoology, Harvard University; W. W. Moss, Academy of Natural Sciences of Philadelphia; E. Munroe, Canadian National Collection; F. H. Rindge, American Museum of Natural History. Drs. Franclemont, William Miller, and Jerry Powell have read parts of the manuscript and made suggestions for its improvement. I thank Amy Louise Trabka for the draw-

ings. This study was supported in part by National Science Foundation Grant DEB 77-15808 and a Grant-in-Aid of Research from the Society of Sigma Xi.

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Journal of the Lepidopterists' Society
33(1), 1979, 28

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POPULATION STRUCTURE AND GENE FREQUENCY ANALYSIS OF SIBLING SPECIES OF *LETHE*

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ABSTRACT. Two recently described sibling species of *Lethe* (*L. appalachia* and *L. eurydice*) exist sympatrically at McLean Bogs Reserve, Tompkins County, New York. We examined the population structure and electrophoretic variation of these two species and found they are substantially different. *L. appalachia* exhibits high vagility in its preferred woodland habitat; delineation of spatial population units was not feasible. *L. eurydice* is philopatric and local in wet meadows; demographic data are easily obtained for this sedentary species. Interspecific comparisons of eight enzyme-synthesizing loci revealed significant differences in allele frequencies at five loci, providing further evidence of two separate gene pools. On the basis of these eight loci, the calculated genetic distance between the two species is 0.145, well within the range of values previously reported for other sibling pairs.

The existence of a pair of sibling species in the genus *Lethe* in eastern North America was proposed several years ago (Cardé, Shapiro and Clench, 1970; Shapiro and Cardé, 1970). It had long been recognized (Field, 1936; Chermock, 1947) that at least two morphologically distinct forms of *Lethe eurydice* occurred in the eastern United States. It was also noted that most reports of this species from northern localities were from open, wet sedge meadows. In the southern portion of the range, however, all reported individuals were observed in deep woods or bush swamp. Chermock had placed all specimens south of Pennsylvania in the subspecies *L. e. appalachia*. Cardé *et al.* recognized that the two forms were, in fact, widely sympatric, habitat-isolated sibling species. They demonstrated that a variety of subtle but consistent morphological characters of adult genitalia and wing patterns as well as larval markings could be used to distinguish the specimens flying in closed woods from those appearing in open meadows. *Lethe eurydice* is the species characteristic of open meadows. Its range extends from southern Alberta and eastern North Dakota to Nova Scotia, and southward to Delaware, Pennsylvania and Ohio. *Lethe appalachia* is restricted to shady, closed canopy woods and bush swamp within sight of water. It is found in the Appalachian ranges from Georgia to Maine, and in the northern part of the range extends westward to Michigan.

A study was undertaken at McLean Bogs Reserve, Tompkins Co., New York to test the accuracy of Cardé and Shapiro's analysis of the *Lethe* situation. A site was chosen for sampling where putative *L. eurydice* habitat was available directly adjacent to *L. appalachia* habitat. A mark-recapture program was begun in the *L. eurydice* habitat (a very well-

marked depression with saturated soil and numerous *Carex* species, surrounded by drier, well-grazed pasture) in order to estimate the density of that population and measure movement of individuals into the wooded area adjacent. A similar program was begun in the woods nearby with *L. appalachia*.

Samples of individuals of each species were captured live and stored for an electrophoretic analysis of genetic variation in the two groups, and for a measurement of their genetic similarity.

METHODS

Mark-recapture analysis of population size

A mark, release and recapture study was undertaken in what will henceforth be referred to as the Pothole area to estimate the density and turnover rate of the *L. eurydice* population there. The population was sampled 14 times during the period from 5 July to 22 July 1975. Insects were netted and secured in glassine envelopes during the 30 minute sampling period. Afterward, each insect captured for the first time was marked with a felt-tipped marker in a coded numerical fashion. The specimen number, sex, and condition of all newly-captured and recaptured insects were recorded; and the individuals were immediately released. The point of release was changed from one day to the next to avoid any overall displacement of individuals by capture. Most samples were taken in the early afternoon.

The data were analyzed using the method outlined by Jolly (1965). This method of analysis is particularly appropriate for use in studies involving three or more successive samples in a population where both dilution and loss are occurring (Southwood, 1966). The basic equation is:

$$\hat{P}_i = (\hat{M}_i n_i) / (r_i)$$

where \hat{P}_i = the estimate of population size on day i , \hat{M}_i = the estimate of the total number of marked animals in the population on day i , n_i = the number of individuals caught on day i , and r_i = the number of previously-marked animals caught on day i .

Other parameters of interest estimated by the Jolly method include $\hat{\phi}_i$ the probability of survival from release time on day i to capture on day $i + 1$, and \hat{B}_i , the number of new animals joining the population in the interval from i to $i + 1$ who are still alive at time $i + 1$.

Electrophoretic analysis of protein polymorphisms

Individuals of *Lethe eurydice* and *L. appalachia* were captured in the field during the period 5 July to 22 July 1975. All 173 individuals of *L.*

eurydice were collected in the Pothole area. Seventy-three individuals of *L. appalachia* were collected in several areas of concentration in the wooded areas of McLean Bogs Reserve. The boundaries of these concentrated areas were very diffuse, however, and individual *L. appalachia* specimens were often netted in other places.

The insects were frozen live after capture and stored at -80°C until electrophoresis. Specimens were prepared for electrophoresis by grinding, after removal of legs and wings, in 0.3 ml of a pH 7.0 buffer of 0.1 M tris, 0.001 M EDTA and 5×10^{-5} M NADP. The homogenates were drawn into capillary tubes, centrifuged at 10,000 rpm for 2 minutes and stored at -80°C .

Horizontal starch gel electrophoresis was performed on the soluble protein extracts by methods similar to those of Selander *et al.* (1971). The buffer systems used and the enzyme assays employed were as follows: lithium hydroxide (Selander *et al.*, 1971, buffer 2), glutamate-oxaloacetate transaminase (GOT), phosphohexose isomerase (PHI) and phosphoglucomutase (PGM); continuous tris-citrate (Selander *et al.*, 1971, buffer 4), malate dehydrogenase (MDH, 2 loci), α -glycerophosphate dehydrogenase (α -GPD), and isocitrate dehydrogenase (IDH, 2 loci). A total of eight enzyme-synthesizing loci were resolved. Five of these were polymorphic in *L. eurydice*, four were polymorphic in *L. appalachia* (a polymorphic locus was defined as one in which the most common allele occurred at a frequency of >0.99). Allele frequencies were estimated directly from the phenotype frequencies for each locus. The formula for heterozygosity of an individual locus is $H = 1 - \sum p_i^2$ where p equals the frequency of an allele at the locus.

An estimate of the genetic distance separating the two populations was made using the method of Nei (1975) which provides an estimate of the mean number of codon differences per structural gene locus. This index may take values from 0, representing populations with no alleles in common, to 1, representing populations with identical frequencies of the same alleles.

RESULTS

Mark-recapture analysis of population size

The calculated estimates of the parameters \hat{P}_i , $\hat{\phi}$, and \hat{B}_i for each day are given in Table 1, and the daily estimates of population size (\hat{P}_i) are shown in Figure 1. These data indicate two distinct peaks in population size: one on 10 July and a second, smaller peak on 14 July. Using a method of graphical estimation (Southwood, 1966) the area under the population estimate curve was calculated and this total, divided by the

TABLE 1. Results of analysis of mark-recapture data.

Day (i)	Proportion of recaptures ($\hat{\alpha}_i$)	No. marked animals at risk (\hat{M}_i)	Survival rate ($\hat{\phi}_i$)	No. of new animals (\hat{B}_i)	Total population (\hat{P}_i)	Standard error of estimation ($\sqrt{V(\hat{P}_i/P)}$)
1	—	0	.553	—	—	0.0
2	.136	16.6	.736	98.3	122.1	72.5
3	.129	24.0	1.15	193.3	186.0	117.0
4	.152	57.5	.941	330.7	378.3	175.9
5	.111	75.8	1.68	166.1	682.9	396.4
6	.210	178.0	.296	-8.5	847.6	375.2
7	.250	60.3	.913	-15.9	241.2	139.0
8	.382	77.0	.410	223.6	201.6	70.5
9	.129	39.4	1.17	-30.9	305.4	202.3
10	.276	75.2	.136	28.8	272.5	111.1
11	.194	(13)	—	—	(65.7)	1.0
12	.093	(03)	—	—	(32.3)	2.0
13	.066	(01)	—	—	(15.2)	2.0
14	.000	(00)	—	—	—	—

average adult lifetime (derived from the mean survival rate $\hat{\phi}_i$), provided an estimate of total population size of 2,912 insects. No *L. eurydice* individuals were ever netted in the woods, nor were any *L. appalachia* caught in the Pothole area.

A similar mark-recapture program was begun with *L. appalachia* at a site in the woods about 100 meters from the *L. eurydice* population. This particular site was chosen because of the consistently higher densities of butterflies observed there in comparison to the woods in general. However, this study was abandoned because of an extremely low rate of recaptures and a general scarcity of *L. appalachia* individuals. In the first four days of the study, 29 specimens were netted, marked and released in 2 manhours of search; only one of these marked individuals was ever recaptured. It became apparent that the site represented only a temporary aggregation point for *L. appalachia*, and not a stable population unit. Individual insects tended to move extensively through large areas of the wooded bog basin, and several similar high-density sites were subsequently found.

Electrophoretic analysis of protein polymorphisms

The frequencies of all alleles for the eight enzyme-synthesizing gene loci for each species are shown in Table 2.

In *Lethe eurydice*, one locus (IDH-II) was represented by a single allele in all individuals. Two loci were dominated by single alleles with frequencies greater than 99 percent (GOT and α -GPD). Two loci were

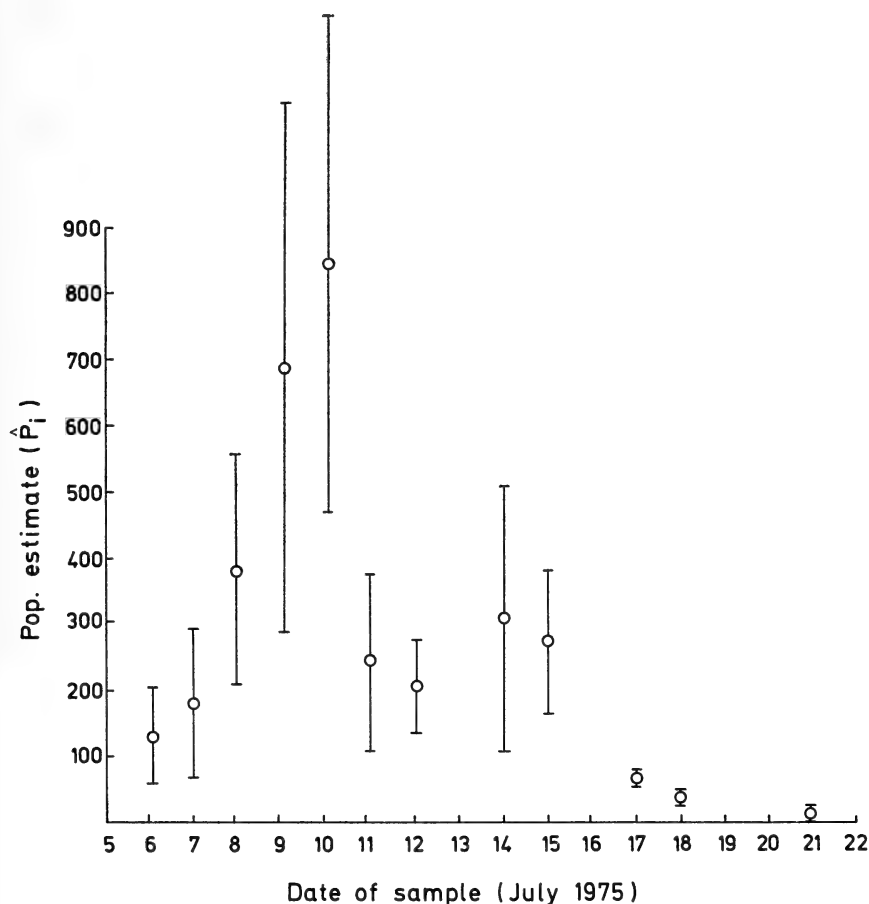


FIG. 1. Daily estimates of population size (\hat{P}_i) for *Lethe eurydice* at McLean Bogs Reserve, Pothole area.

dominated by single alleles with frequencies greater than 95 percent but less than 99 percent (MDH-I and MDH-II). Of the other three polymorphic loci, one locus had two alleles represented in the population (IDH-I), one locus had three alleles (PHI), and one locus had four alleles (PGM).

The mean heterozygosity for the population is 0.175. The heterozygosities of individual loci are listed in Table 3. The genotype frequencies at all loci were not significantly different from those predicted by the Hardy-Weinberg expression using the χ^2 goodness-of-fit test (Sokal and Rohlf, 1969).

Lethe appalachia showed a similar pattern of electromorphic variation.

TABLE 2. Results of analysis of allozyme variation.

Locus	Allele	<i>Lethe eurydice</i>		<i>Lethe appalachia</i>		Results of G-test ($p =$)
		Allele frequency	Sample size	Allele frequency	Sample size	
GOT	a'	—	320	.012	162	N.S.
	a	.977		.988		
	b	.003		—		
PHI	a	.103	340	—	164	<.001
	b	.679		.561		
	c	.240		.421		
	d	—		.018		
PGM	a	.321	308	.488	162	<.001
	b	.546		.265		
	c	.127		.204		
	d	.006		.043		
MDH-I	a	.034	320	.006	162	.036
	b	.966		.994		
MDH-II	a	.975	320	1.00	162	.01
	b	.025		—		
α -GPD	b	.993	320	1.00	162	N.S.
	c	.007		—		
IDH-II	a	.876	322	.988	162	<.001
	b	.122		.012		
IDH-II	a	1.00	226	1.00	150	N.S.

Three loci (MDH-II, α -GPD and IDH-II) were represented in the population by single alleles. One locus (MDH-I) was strongly dominated by an allele with a frequency greater than 99 percent. Two loci (GOT and IDH-I) were dominated by single alleles with frequencies between 95 and 99 percent. The remaining two loci had three (PHI) and four (PGM) alleles present in the population.

TABLE 3. Estimates of heterozygosity per locus.

Locus	<i>Lethe eurydice</i>	<i>Lethe appalachia</i>
GOT	.006	.024
PHI	.470	.508
PGM	.583	.648
MDH-I	.066	.012
MDH-II	.048	.000
α -GPD	.014	.000
IDH-I	.212	.024
IDH-II	.000	.000
Mean	.175	.152

The mean heterozygosity of the *L. appalachia* population was 0.152. Heterozygosities of individual loci can be found in Table 3. No locus showed significant deviation from Hardy-Weinberg expectation using the χ^2 goodness-of-fit test.

The two species are highly significantly different ($p < .01$, G-test) in allele frequencies at four of the eight loci examined, and significantly different ($p = .036$) at another. These data clearly indicate reproductive isolation in sympatry. Using the genetic distance measure of Nei (1975) the distance separating these species equals 0.145, a figure well within the rather wide range of available estimates of distances separating sibling pairs. (Nei's measure can range between a maximum distance of 1.00, representing no alleles in common, to a minimum of 0.0, representing total identity.)

A very small number of individuals (six) of *Lethe portlandia* captured at the McLean Bogs Reserve were analysed at the same eight enzyme loci. Although the sample size was insignificant for statistical purposes, the electromorphs at six of the loci tested represented clearly different mobility classes from those present in either *L. appalachia* or *L. eurydice*.

DISCUSSION

The results of this study fully agree with the conclusion of Cardé, Shapiro and Clench (1970) and Shapiro and Cardé (1970) that the butterflies *Lethe eurydice* and *L. appalachia* are distinct, although very similar, sibling species. Both the mark-recapture study and the analysis of genetic variation demonstrate that the two are genetically isolated and habitat-segregated, at least in the locality studied.

The mark-recapture study indicates that the two species strongly resist crossing over from the open to the wooded habitat, or vice versa. It also suggests that the two populations have contrasting spatial structure. *Lethe eurydice* occupies a small, isolated, concentrated, uniform patch of acceptable habitat, while *L. appalachia* occupies a more "fine-grained" habitat, moving extensively between more fragmented and diffuse sites of maximum acceptability.

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Journal of the Lepidopterists' Society
33(1), 1979, 36

NOTES AND NEWS

THE JAMES H. BAKER COLLECTION

The James H. Baker collection of insects has been received at the Department of Entomology, Smithsonian Institution. Baker's material consists of slightly more than 24,400 specimens, primarily Lepidoptera, but also contains many Coleoptera and Diptera.

Among the Lepidoptera the collection is especially rich in Geometridae, Baker's specialty. Most of the specimens in this collection are from eastern Oregon, but Baker enjoyed a wide correspondence and traded considerably; consequently there is a rather liberal sprinkling of moths and butterflies from localities other than Baker's home state. Baker also collected in such places as Arizona, Idaho, and Nevada, so there is a nice representation of species from those areas.

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THE LARVA OF *CRYPTOCALA ACADIENSIS* (BETHUNE) (NOCTUIDAE)¹

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ABSTRACT. The mature larva of *Cryptocala acadiensis* (Beth.) (Lepidoptera: Noctuidae) is described. *Apocynum androsaemifolium* L. was found to be an acceptable food plant; additional acceptable and unacceptable food plants are listed. Eggs were laid singly and the minimum developmental time from egg to adult was 116 days in the laboratory. This is a much shorter developmental time than what would be expected in nature as the mature larva is presumed to overwinter.

In the type description, *Cryptocala acadiensis* (Bethune, 1869) was placed in the genus *Anarta* Ochseneimer because of its small size and black bordered, yellow hind wings. Benjamin (1921) recognized it as a synonym and the older name for *Rhynchagrotis gilvipennis* (Grote) and erected *Cryptocala* for it. Prior to this paper nothing was known of the life history. Mikkola and Jalas (1977) report that *Rumex* is the host plant of the very close (if actually distinct) species, *Noctua* (*Cryptocala*) *char-dinyi* Boisduval.

Cryptocala acadiensis occurs from Labrador south to Massachusetts and west to the Pacific. Its flight period is from July to August (Forbes, 1954). A female of *C. acadiensis* was taken at ultraviolet light on 16 July 1977 in the Adirondacks, 6 mi east of Indian Lake, 1820 ft, Hamilton Co., New York. The following day 39 eggs were laid singly in a holding jar. The larvae eclosed in seven days and were offered a selection of plants.

The first instar larvae initially accepted the blossoms of *Hypericum perforatum* L., *Sagittaria latifolia* Willd., the blossoms and leaves of *Apocynum androsaemifolium* L., and the leaves of *Prunus virginiana* L., *Achillea millefolium* L., *Sambucus canadensis* L., and *Spiraea latifolia* (Ait.) Borkh., but the limited feeding and continual wandering of the first instar larvae indicated that most of these plants were unacceptable. Only *A. androsaemifolium* was continuously utilized by the first instar larvae and all later instars were reared to maturity on *A. androsaemifolium* leaves. Plants refused by the first instar larvae include: *Rubus idaeus* L., *Ame-lanchier laevis* Wieg., *Pteridium aquilinum* (L.) Kuhn, and *Vaccinium myrtilloides* Michx.

The larvae feeding on *A. androsaemifolium* remained healthy (no disease) but grew slowly. They started pupating on 12 September 1977 and adults began to emerge on 10 November 1977. Presumably, this species would normally overwinter as a mature larva and pupate in the spring.

¹ Published by permission of the Director, New York State Museum, Journal Series No. 254.



FIG. 1. *Cryptocala acadiensis*, Adirondack Mts., New York: photograph of living, ultimate instar larva.

The larvae were cultured in tins in total darkness (interrupted only by the addition of fresh leaves every two days) at 22°C ($\pm 3^{\circ}$). These artificial conditions speeded development as is the case with many species which normally feed at night. The early pupation is also typical of many Lepidoptera which have a non-obligatory diapause.

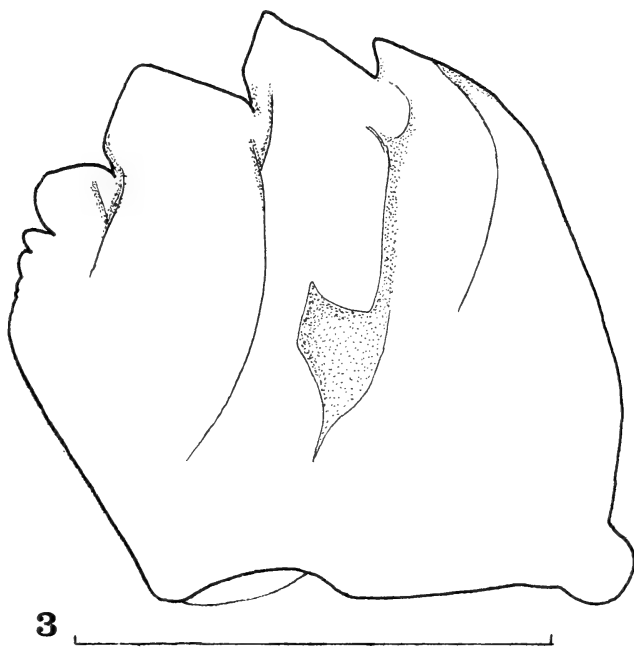
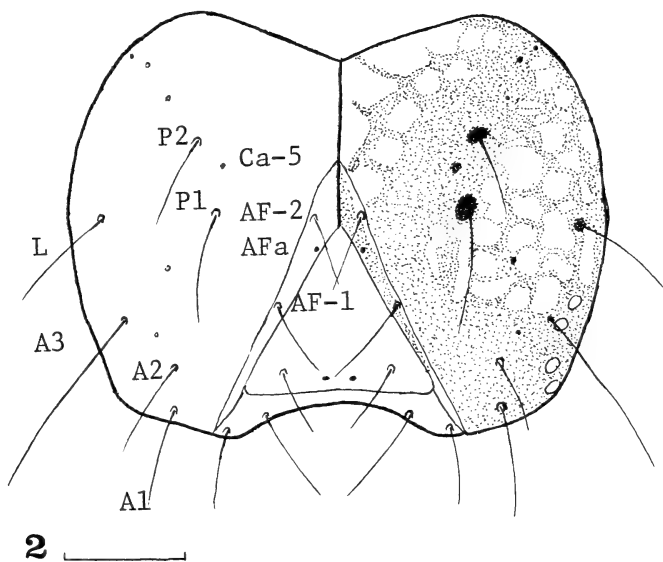
The illustrations that accompany the descriptions of the last larval instar were drawn to scale using an ocular grid. All scale lines represent 0.5 mm. The terminology and abbreviations follow Godfrey (1972) with the exception of coronal punctures.

General (Fig. 1). Head 2.06–2.23 mm wide. Total length 26–30 mm. Abdominal prolegs present on third through sixth segments. Head and body smooth. Setae simple, insertions in small, flat, black tubercles. Spiracle A-8 0.28 mm high. Seta D1 0.40 mm long.

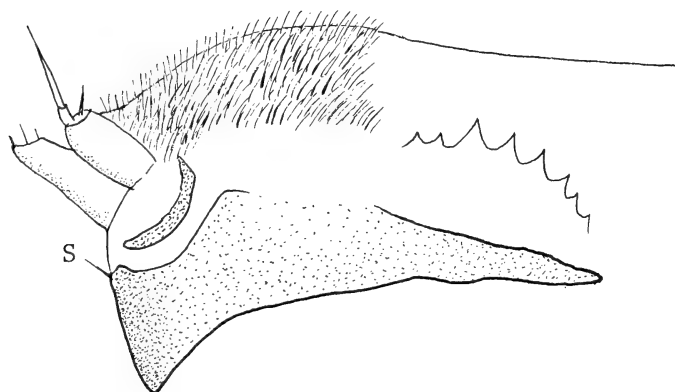
Coloration (living material). General head and body color light brown; a light middorsal line and a light line just below D2 on all segments; venter below spiracles light; spiracles also light.

Head (Fig. 2). Epicranial suture 1.04 mm long. Height of frons 1.40 mm. Adfrontal punctures (AFa) anterior and second adfrontal seta (Af-2) posterior to apex of frons. Coronal punctures 5 (Ca-5), posterior setae 1 & 2 (P1 & P2), and lateral seta (L) each arise from a black pigmented spot. Ocellar interspaces between Oc1–Oc2 and Oc2–Oc3 each equal to diameter of Oc2; Oc3–Oc4 one-third diameter of Oc4; Oc4–Oc6 approximately 1.5 times diameter of Oc4; Oc4–Oc5 2.0 times the diameter of Oc4.

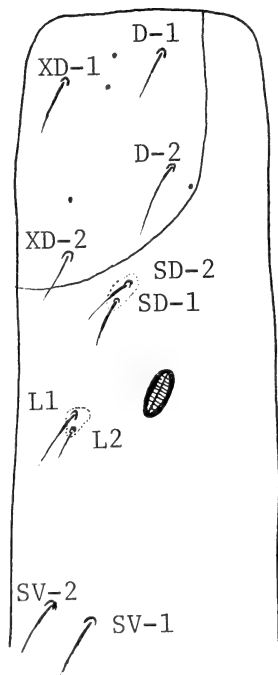
Mouthparts. Hypopharyngeal complex (Fig. 3): spinneret subsequential to labial palpus, apex bearing short spinules; stipular seta (S) at anterior dorsal apex of pre-



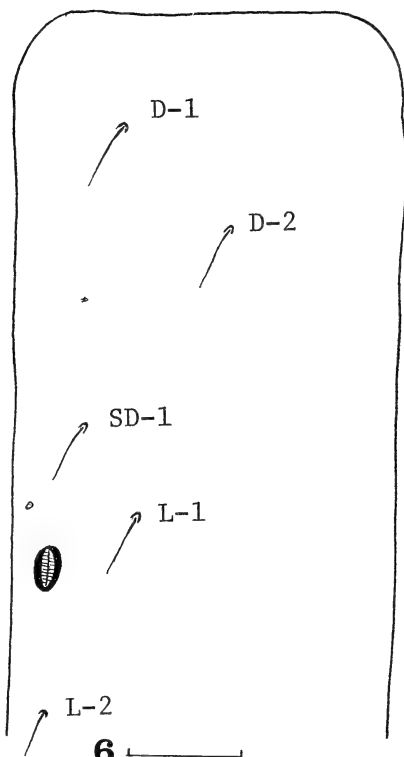
FIGS. 2-3. *Cryptocala acadiensis*, Adirondack Mts., New York: 2, frontal aspect of head; 3, oral aspect of left mandible.



4



5



6

FIGS. 4-6. *Cryptocala acadensis*, Adirondack Mts., New York: 4, left aspect of hypopharyngeal complex; 5, left dorsolateral setal arrangement of prothorax; 6, left dorsolateral setal arrangement of first abdominal segment.

mentum; distal region of hypopharynx covered with fine spines; proximolateral region bearing single row of about 8 distinct spines. **Mandible** (Fig. 3): inner ridges distinct, with prominent basal tooth; sixth outer tooth low, divided into smaller subteeth.

Thoracic segments. **Prothorax** (Fig. 5): cervical shield weakly sclerotized, with two punctures between setae D-1 and XD-1, one puncture between XD-1 and XD-2 (located two-thirds distance from XD-1 to XD-2) and one puncture along posterior margin of shield behind D-2; SD-1 and SD-2 on same pinaculum; L1 and L2 also on same pinaculum; SV-1 and SV-2 separate. **Meso- and metathoracic segments** with a non-setiferous puncture on same pinaculum as SD-1.

Abdominal segments. **Ab-1** (Fig. 6): two subventral setae (SV-1 & SV-3); L1 dorsal to spiracle. **Ab-2-6** with three subventral setae. **Ab-7 and Ab-8** with only one setae in subventral group. **Crochets:** uniordinal, 16-17 per third abdominal proleg, 18-21 per fourth, 20-24 per fifth, 22-26 per sixth.

Material examined. Thirteen specimens, 6 miles east of Indian Lake, 1820 ft., lat. 43°45'30" long. 74°10'14", Hamilton Co., New York, 10 September 1977, from ova of female collected, determined, and reared by T. L. McCabe.

The basal mandibular tooth and the spinule-tipped spinneret seem to indicate a relationship to *Ochropleura plecta* (L.) (see Crumb, 1956, for larval description), but this is not substantiated by the male genitalia (figured by McDunnough, 1928).

ACKNOWLEDGMENTS

I thank Drs. J. G. Franclemont and G. L. Godfrey for reviewing this manuscript. Mr. Stanley J. Smith verified the plant determinations and voucher plant specimens are deposited in the New York State Museum. Funds have been provided by the New York State Museum, Albany, New York.

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COURTSHIP BEHAVIOR OF THE CHECKERED WHITE, *PIERIS PROTODICE* (PIERIDAE)

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ABSTRACT. Courtship behavior leading to copulation is described for the checkered white, *Pieris protodice*, from film records of courtships with perched virgin females and written records of courtships elicited by releasing virgin females near free-flying males. Temporal and sequential patterns of successful courtships follow those seen in other pierid butterflies in that the interactions are simple and rapid, averaging about 3 seconds in duration. Unsuccessful courtships are also described and conform to patterns documented for other pierids. The checkered white differs from con-familials only in that there is no abdominal extension by females during successful courtship and after copulation a post-nuptial flight may occur. The possible functions of post-nuptial flights are discussed.

Although ethologists have been interested in butterfly courtship for many years (Scott, 1974; Silberglied, 1975) few quantitative studies of the temporal and sequential structure of butterfly courtship can be found in the literature. Detailed information is essential for comparative studies of butterfly courtship which in the past have proven useful in deducing the ecological factors influencing the structure of both successful and unsuccessful courtships (Brower *et al.*, 1965; Pliske, 1975; Rutowski, 1978a).

In this paper the courtship of the checkered white, *Pieris protodice* Boisduval and Le Conte, is described in detail. Attention will be focused on the structure of successful courtships so that this account can be compared to previous studies of a similar nature, with special reference to the function of post-nuptial flights in butterflies. It should be noted that a brief description of *P. protodice* courtship was given in Abbott (1959). However, Shapiro (1970) has pointed out the interpretational problems surrounding that description, so it will not be dealt with here.

METHODS

All observations were made and all animals obtained from March through June in 1976 and 1977 at the Arizona State University Field Laboratory, Tempe, Arizona. To obtain virgin females, eggs were collected by placing field-caught females in tubular cheesecloth cages (1 m high, 0.28 m diameter) with cuttings of the local larval foodplant, *Sisymbrium irio* L. The larvae from these eggs were reared to adulthood in the laboratory on *S. irio*. The humidity and light regimen in the rearing area were not regulated and variable.

All behavioral observations were made on clear days between 0900 and 1500 when the butterflies were most active. Naturally-occurring interactions between males and between males and females were observed and the form, outcome, and duration (as timed with a stopwatch) of each recorded. Similar records were made of interactions initiated by releasing virgins near free-flying males.

During late May 1977, films of successful courtships were made at 24 and 70 frames per second using a Beaulieu 4008 ZM II super-8 movie camera. In all cases a virgin female was placed near the top of an exposed perch in a large patch of *S. irio* where there was a dense population of flying males. By activating the camera as a male approached a complete record of the courtship could be obtained. Temporal and sequential data were gathered via frame-by-frame analysis of the film records.

Where pertinent, summary statistics are given as mean \pm standard error of the mean.

RESULTS

I. Successful Courtship

Using 38 virgin females, 27 successful courtships (= ending in copulation) were recorded on film and 58 were observed after releasing virgin females near free-flying males. Temporal data from the films will be summarized first to give a general impression of the structure of *P. proto-dice* courtship.

A. Film records

Successful courtship with a perched female began when the male's wings or legs made physical contact with the female. In 67 percent of the filmed courtships this contact was made with the legs as the male alit on the female and immediately walked toward her thorax. In all other film records the male broke and then renewed contact with the female at least once, and as many as four times, before positioning himself on the female's thorax. Once on the female's thorax in a head-to-head orientation the male curled his abdomen out from between his hindwings and inserted the tip between the female's hindwings, often after several unsuccessful attempts. It was not possible to determine when genital contact was made. The courtship ended when the male stopped moving his wings and assumed a quiescent posture. Males showed no preference for the side of the female from which they effected copulation (13 right vs. 14 left; $\chi^2 = 0.037$, $p = 0.85$).

Fig. 1 shows the temporal pattern of the following major events in a successful courtship with a perched female: male contacts female, male

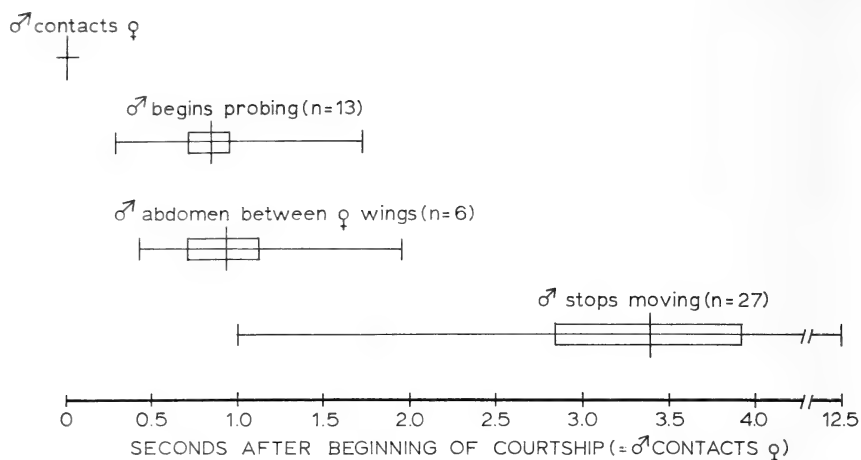


FIG. 1. Temporal relationships between the major behavioral events in the successful courtship of *P. protodice*. The mean time of occurrence, standard error (open bar), range line, and sample size (n) are shown for each behavior. See text for details.

begins probing (abdomen appears from between hindwings), male abdomen between female hindwings, male stops moving. There were no observed variations in the sequence of these events. In 45 percent of the courtships the female performed a low amplitude flutter response. Of these, 25 percent began before the male first contact and 75 percent after, and they ended most often before the male began probing but sometimes not until he had inserted his abdomen between the female's hindwings. Detailed quantitative information on these points was difficult to gather because of 1) the viewing angle of many of the film records and 2) the low amplitude of the flutter response. In any event, flutter responses had no significant effect on the duration of courtship (courtships with flutter response: 2.8 ± 0.37 sec, $n = 12$; courtships without flutter response: 3.86 ± 0.93 sec, $n = 15$; $t = 0.968$, $p = 0.66$).

Shortly after coupling some males attempted to fly away from the perch carrying the female. In the 11 courtships where these attempts were filmed the males broke contact with the perch on the average 3.71 ± 0.586 sec (range = 1.71–7.34 sec) after they had stopped moving their wings. In 8 of these attempted "post-nuptial flights" (Brower *et al.*, 1965) the female did not release her grip on the perch and the male dangled from the female's abdomen at the end of the attempt. In the other 3 cases the male flew off carrying the female to a distant and usually less exposed perch. Systematic data on these points or on the duration of successful post-nuptial flights was not collected.

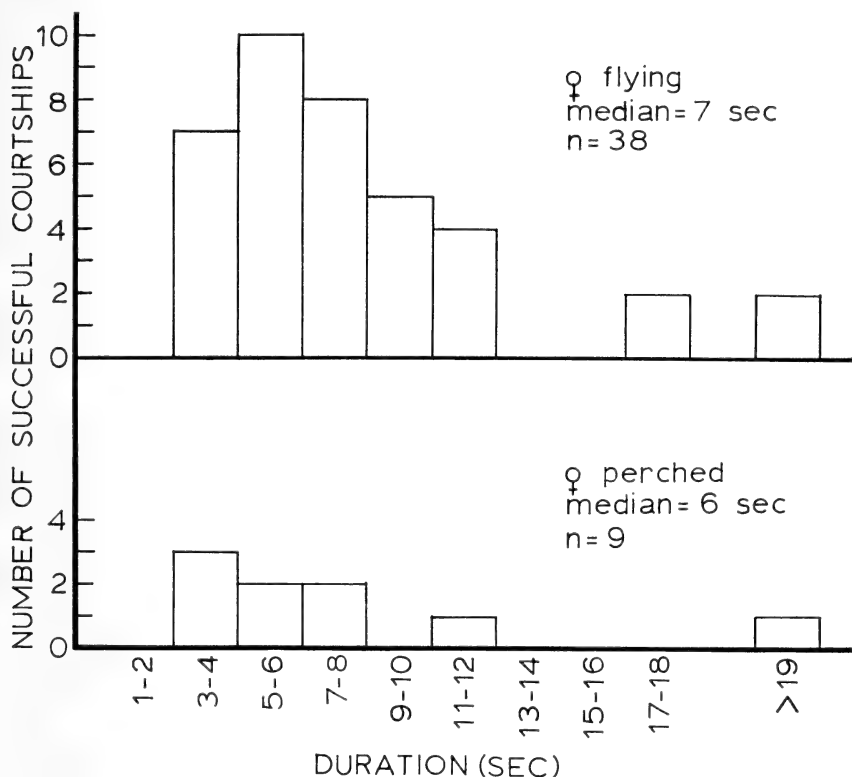


FIG. 2. A frequency histogram of the duration of successful courtships with perched and flying females. Courtships were elicited by releasing females near free-flying males and were timed with a stopwatch. n = number of courtships.

B. Written records

The successful courtships elicited by releasing virgin females near free-flying males were timed beginning when the two animals arrived within 1 to 2 cm of each other. The distance at which these observations were made did not allow the use of contact as a criterion for when courtship began. This coupled with the lack of precision in determining when courtship ended resulted in the apparent greater length of these courtships relative to those timed from film records. These courtships were divided into two groups depending on whether the female was flying or perched when the male arrived within 1 to 2 cm of her (Fig. 2). The differences between these two types of courtships in the distribution of durations and median durations were slight suggesting that aerial components were of short duration. In fact, flying females typically landed immediately when approached by a male. The form and sequence of all

ground components of these courtships were exactly like those described from the film records.

Post-nuptial flights were attempted in 27 of the 58 successful courtships with released females. This should not be taken as an absolute indicator of the frequency of attempted post-nuptial flights because no firm protocol was established for how long a copulating pair should be watched after the courtship to wait for the onset of a post-nuptial flight attempt. Of the observed attempts 9 were unsuccessful, i.e., the female did not release her grip on the perch where copulation occurred.

The duration of copulation was timed for 15 pairs. Thirteen of these pairs copulated for less than 35 min (27.2 ± 1.17 min). The other two pairs copulated for 179 and 236 minutes, respectively.

II. Unsuccessful Courtships

Interactions between males and virgin females that did not result in copulation are here referred to as unsuccessful courtships. Film records of unsuccessful courtships were not made because of the great variation in their form and duration. Data on the following five general types were derived from written records of 34 unsuccessful courtships between males and released virgins. The number of observations (n) and the percent of all documented unsuccessful courtships is given for each type. All types terminated when the male departed.

Type A. The female continued flying on a level course ($n = 17$, 50%). These interactions were of short duration (2 to 15 sec). The males were probably of low courtship persistence like those seen by Rutowski (1978b) in *Colias* butterflies.

Type B. The female continued flying and initiated an ascending flight ($n = 1$, 3%). As well as the one interaction with a virgin female, seven naturally-occurring interactions were seen in which the females (presumably mated, see Shapiro, 1970) initiated ascending flights when courted by males. The interactions ranged in duration from 5 to more than 35 sec. Since all observed ascending flights were between males and females and since none ended in copulation it is assumed that they were attempts by mated females to curtail the courtship of persistent males as has been documented for the ascending flights of *Colias* butterflies (Rutowski, 1978b).

Type C. The female alit on vegetation or on the ground; the male may or may not have attempted copulation ($n = 7$, 20%). Since these unsuccessful courtships ranged in duration from 3 to 10 sec, the males were probably of low persistence as in type A.

Type D. The female alit on vegetation or on the ground and performed a flutter response, a pierid mate refusal posture, or both ($n = 9$, 26%). These interactions were from 10 to 68 sec in duration. When perched females spread their wings and elevated the abdomen they were said to have performed the mate refusal posture first described by Obara (1964) for *P. rapae* and reported for several other pierids (Scott, 1973). Abbott (1959) previously and incorrectly described the mate-refusal posture as an immediate invitation to copulation in *P. protodice*. This posture mechanically impedes the male's copulatory attempts. Females achieved the same effect in other situations by performing the flutter response, a rapid opening and closing of the wings (Obara, 1964; Rutowski, 1978a).

Type E. The male was displaced by another male ($n = 1$, 3%). This was only seen once with a virgin although I have also seen it occur with wild females. A

courting male terminated his courtship attempt when another male approached the female and began courtship. The second male was also unsuccessful. The female in this case was perched during the displacement. In naturally occurring unsuccessful courtships two males courting the same perched or flying female may leave together while circling each other in rapid flight.

Systematic observations of unsuccessful courtships with mated females were not made but casual observation suggests that they may only be of type A, B, D, or E. Shapiro (1970) noted that such courtships may be very lengthy in duration, up to 30 min or more.

DISCUSSION

Successful courtship in *Pieris protodice* is rapid and highly stereotyped. There are no prolonged aerial components and once the female alights on vegetation or on the ground the male does little more than land on her thorax and couple with her. This description closely fits that given for the temporal and sequential characteristics of the courtships of other pierids including *Eurema lisa* Boisduval (Rutowski, 1978a), *Colias eurytheme* Boisduval, *C. philodice* Latreille (Silberglied and Taylor, 1978), and four species of *Pieris* in Japan (Suzuki *et al.*, 1977). *Pieris protodice* also shares components of its courtship with *Leptidea synapsis* Linnaeus although the latter's courtship is apparently longer and includes some striking male displays (Wiklund, 1977). However, the most obvious difference between the courtship of species in the genus *Pieris* and that of other pierids is the lack of an abdominal extension response on the part of the female. In *E. lisa*, *L. synapsis*, and *Colias* species the male cannot couple with the female unless she extends her abdomen ventrally out from between the hindwings. Chemical and tactile cues delivered as the male courts the female elicit this response in *E. lisa* females (Rutowski, 1977). A male of *P. protodice* must insert his abdomen between the female's hindwings to reach her abdomen and couple. At present the proximate and ultimate causes of this variation are unknown.

The unsuccessful courtships of *P. protodice* also follow patterns observed in other pierids. Males vary in persistence and females utilize mate refusal postures, flutter responses, and ascending flights to curtail or impede the copulatory attempts of persistent males. Interestingly, all three behavior patterns were displayed by virgins as well as mated females suggesting that males vary in their attractiveness to virgin females which may be selective in their choice of a mating partner. Similar responses to males by virgin *E. lisa* females have been hypothesized to serve the same function (Rutowski, 1978a). The rejection responses of virgin *Colias* females definitely play a role in avoiding courtships with males of the wrong species (Taylor, 1973).

Post-nuptial flights have been previously reported only for danaids by

Brower *et al.* (1965) and Pliske (1975). It should be noted that these post-nuptial flights are spontaneous and as such are distinguished from the induced flights of copulating pairs summarized in Shields and Emmel (1973). To date the only function attributed to post-nuptial flights is that of removing the copulating pair from the place where courtship activity has made them conspicuous to one where they are less visible (Brower *et al.*, 1965). In *P. protodice* courtships, females often land on exposed perches. Presumably this facilitates copulation since males frequently appear to have trouble locating and mating with females that land in dense vegetation. Thus, post-nuptial flights in this species may also serve an anti-predator function. As an extension of this hypothesis, post-nuptial flights may also remove animals from exposed perches where thermal stress might become a problem, especially on warm days.

The selective pressures of predation and thermal stress should act equally on copulating males and females. However, the data clearly indicate that males and females are not equally willing to participate in post-nuptial flights. I suggest that there may be conflict between males and females as a result of male-male competition. Most courtships occur in or near stands of larval foodplant where males look for receptive ovipositing females or newly-eclosed virgin females. During copulation, pairs are often buffeted by single males in a way that makes them conspicuous to potential predators or may result in the separation of the pair. From the male's perspective both would be detrimental to his fitness and select for copulating males who initiate post-nuptial flights and move to areas of low male density. However, from the female's perspective it may be advantageous to remain in the vicinity of a stand of larval foodplant for the following reason. Because males do not defend resources of interest to females, females may select males only on the basis of behavioral cues that are correlated with high genetic quality. One of these cues may be the male's ability to defend the pair against interruptions by other males during copulation. If so, then it may be to the female's advantage to stay in an area of high male density thereby forcing the male to fend off the onslaughts of other males. If he cannot, then the female might benefit by copulating with another male.

In summary, I propose that selection does not act equally on males and females with respect to their participation in post-nuptial flights. In particular, there appear to be ecological circumstances in which males benefit from post-nuptial flights but at least some females do not because the potential benefits of preventing post-nuptial flights and inciting male-male competition outweigh the potential costs of increased predation and

thermal stress. The ecological conditions that give rise to this situation remain to be defined.

ACKNOWLEDGMENTS

I thank Dr. John Alcock for his critical reading of the manuscript and Mr. Larry Marshall for his assistance in the field. This study was supported in part by an Arizona State University Faculty Grant-in-Aid and National Science Foundation Grant BNS 78-11211.

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A NEW TECHNIQUE FOR THE PROSPECTIVE SURVEY OF SEX CHROMATIN USING THE LARVAE OF LEPIDOPTERA

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ABSTRACT. A way of examining the heteropyknotic body is described, using cells from prolegs amputated from living larvae. Larval survival rate is high and the results are accurate. Prospective testing for the presence or absence of sex chromatin is particularly valuable in studying intersexes, e.g., in *Lymantria dispar*, where the adult phenotype is not necessarily an indication of the chromosome constitution of the larva.

It is well known that in Lepidoptera a heteropyknotic body may be found in the somatic cells of the female whereas it is lacking in the male (Smith, 1945). However, there are some exceptions to this rule (Traut and Mosbacher, 1968); for example, in *Papilio machaon* L. the male is polymorphic for the character (Clarke *et al.*, 1977). There is also good evidence that in the female the body is derived from the W(=Y) chromosome (Suomalainen, 1969; Traut and Rathjens, 1973) and that where it is present in the male it is associated with a particular autosome (Clarke *et al.*, 1977).

Testing for the "Smith" status has usually been carried out on freshly killed larvae or adults, but Daker (1977) showed that in *Hypolimnias bolina* L. it was possible to assess it from a spine taken from a living larva which thereafter usually developed normally.

In the present paper we show that it is also possible to obtain good preparations using a proleg of last instar larvae. We, in fact, found that our preparations from prolegs were of better quality than those from spines. Moreover, this method is particularly useful in dealing with larvae which have no spines.

MATERIALS AND METHODS

The species investigated were *Papilio glaucus* L., *Papilio dardanus* Brown, *Euploea core amymone* Cr., *Hypolimnias bolina* L. and *Lymantria dispar* L.

The *P. glaucus* stock was bred at Caldy, Wirral, and derived from two females from Virginia, U.S.A., kindly supplied by Prof. J. J. Murray. Mrs. Jennifer Maddison of Ibadan sent the butterflies from which all the Nigerian *P. dardanus* stock was bred and Mrs. Gweneth Johnston posted to us living *E. core* butterflies from Hong Kong which produced the tested larvae. In *H. bolina*, race hybrid stock was used, the parent forms coming from Sarawak (from Mr. Stephen Kueh) and Sri Lanka (from Mr.



FIG. 1. Proleg tip of *H. bolina* larva showing tissue scraped out. (As seen under dissecting microscope.)

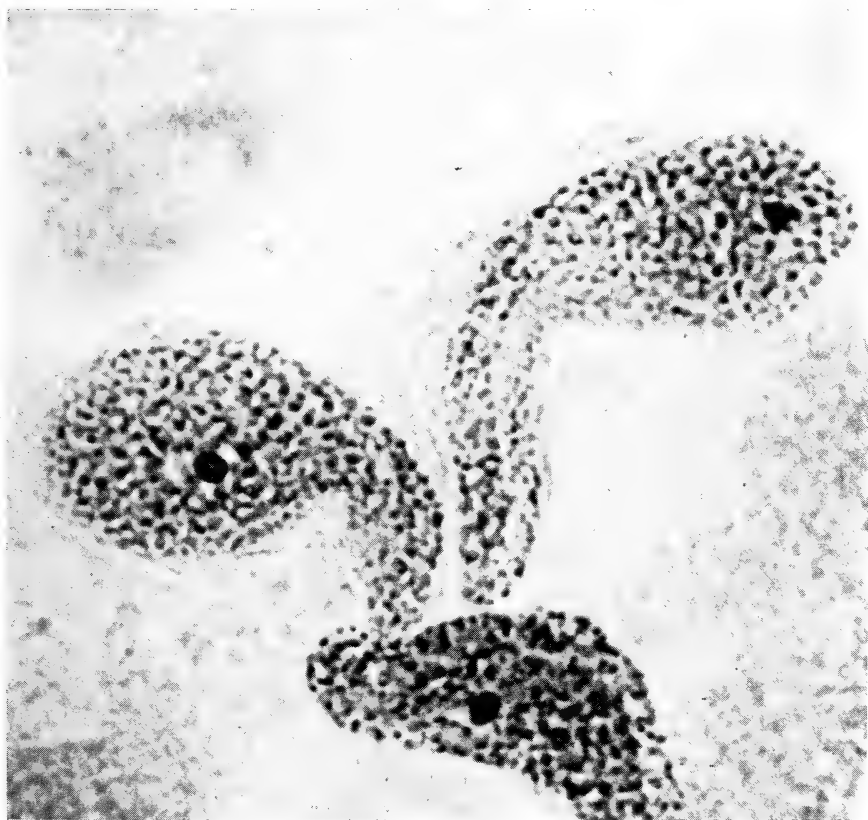


FIG. 2. Nuclei of tissue cells containing heteropyknotic body from a larva which developed into a female butterfly. (Using $\times 90$ —oil immersion—objective.)

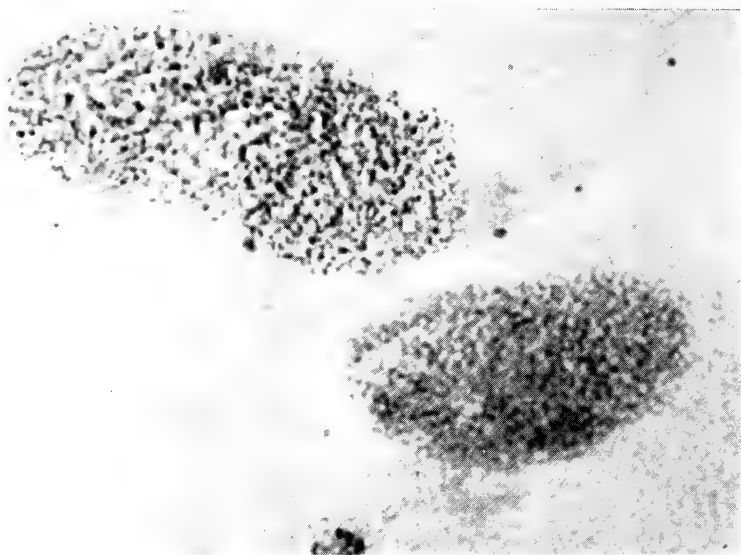


FIG. 3. Nuclei of tissue cells lacking heteropyknotic body from a larva which developed into a male butterfly. (Using $\times 90$ —oil immersion—objective.) Editor's note: photograph reduced to $\frac{3}{4}$ size of original.

P. B. Karunaratne. The pure Japanese broods of *L. dispar* originated from a wild Nagoya female supplied by Dr. Shigeru Ae, and the hybrid brood was from a mating between a German female (from Herr Willy Schultz) and a bred Nagoya male.

In the early experiments, the larva to be tested was lightly anesthetized, and then the extreme tip of one of the abdominal prolegs (Fig. 1) was removed with a sharp pair of dissecting scissors. Later it was found that better survival was obtained without an anesthetic. Enough tissue can be scraped from the inside of the proleg to make one good preparation; the material is teased out and spread as thinly as possible. After the amputation each larva was kept separately.

The cells are not fixed before staining. Two drops of 2% orcein in 45% acetic acid are placed over the tissue and a coverslip added immediately. After 10–15 minutes the coverslip is firmly pressed to make a "squash" preparation. The "Smith" body when present can be clearly seen under the $\times 40$ objective as well as under the $\times 90$ (oil immersion) objective (Figs. 2 & 3).

RESULTS

Results are shown in Table 1. The accuracy of the method is assessed by noting the sex of the butterfly or moth when it emerges, and in the

TABLE 1. Adult emergences and pupae (sexed externally) from several species of Lepidoptera tested for sex chromatin using cells from the larval proleg.

Brood no. & species	No. of larvae tested for "Smith" body	Sex chromatin assessment of larvae	Emergences from tested larvae	Deaths in larval & pupal stages	Overwintering tested pupae sexed externally
15050 <i>P. glaucus</i> ex black female form	9	8 positive 1 negative	6 black females 1 male	2 positive —	— —
15094 <i>P. glaucus</i> ex yellow female form	19	10 positive 9 negative	1 yellow female —	5 positive 4 negative	6 females ¹ 3 males
15219 Joint no. given to several generations of <i>P. dardanus</i> ex female <i>hippocoon</i>	14	1 positive ² 13 negative	— 2 females, 8 males	1 positive 3 negative ³	— —
509z Joint no. given to several generations of <i>E. core anymone</i>	3	1 positive 2 negative	1 female 1 male	— 1 negative	— —
524z Joint no. given to several generations of <i>H. bolina</i> hybrids Sarawak × Sri Lanka	22	11 positive 11 negative	6 females 5 males	5 positive 6 negative	— —
14983 & 14984 <i>L. dispar</i> Japanese race	12	6 positive 6 negative	5 females 3 males	1 positive 3 negative	— —
14985 <i>L. dispar</i> F1 race cross ♀ German × ♂ Japanese	14	12 positive 2 negative	10 females 2 males	2 positive —	— —

¹ Two of these 6 female pupae developed from "Smith" negative larvae. To date, 4 yellow females have emerged from this brood; 2 were "Smith" positive and were "Smith" negative.

² This was the only positive finding in at least 40 insects of both sexes in this brood, tested at various stages of development. Unfortunately the larva died and the cell nuclei were too degenerate to perform a confirmatory test.

³ These 3 insects were killed when moribund and the test was confirmed as "Smith" negative on gut cells.

case of overwintering insects, by scoring the sex of the pupa by its external appearance. Concordance between the larval score and the adult or pupal sex is high.

DISCUSSION

Several points are of interest:

In *P. glaucus*, it had been reported previously (Clarke *et al.*, 1976) that the black females were "Smith" positive and the yellow ones (which are male-like) and the males were negative. It is now clear that frequently yellow females are positive, and there appears to be a polymorphism for the character in the yellow form. All black females have, however, so far been positive.

In *P. dardanus*, in the present material, the *hippocoön* females are consistently negative, though previously a few insects of this and other female forms have been positive, so that here again there is a polymorphism.

This information in both these species could clearly have been obtained without sexing the larva, but prospective testing has the great advantage that it is possible to select and breed from a female of known "Smith" status. Moreover, it obviates the necessity of testing her immediately after death which is obligatory because rapid degeneration of the cell nuclei occurs post-mortem.

The most valuable application of the method, however, will become evident when *L. dispar* is further studied. Here, in race crosses, intersexes may occur (Goldschmidt, 1933), and it will be most informative to relate the sex chromatin status to the phenotype and to the gonadal morphology.

ACKNOWLEDGMENTS

We are extremely grateful to Sir Cyril Clarke F.R.S. for his help in writing this paper and for the use of his facilities and livestock, to Mr. Maurice Gill for taking the photographs and to all those named in the text who kindly provided the living material.

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BOOK REVIEW

BUTTERFLIES. Text by Jo Brewer, photographs by Kjell B. Sandved. 1976. Harry N. Abrams, New York. 176 pp., ill. Price: hardcover, \$18.95; softcover, \$9.95, U.S.

In the last few years a number of fine popular volumes with exquisitely colored plates have been published, but none has had such an innovative and refreshing approach as this book. Since it is broad in scope and supplies the necessary basic information for the study of Lepidoptera in the clear, concise manner for which Brewer is duly noted, the book should stimulate an interest in and appreciation for the insect group from a technical as well as an aesthetic point of view. It is well illustrated with 245 photographs (133 in color) and additional line drawings and scanning electron micrographs.

The organization of the book is quite a departure from traditional treatments. There is a section on the economic impact of butterflies on man ("Historical Notes on Butterflies, Moths and Men"). The section on "Butterflies in Art, Heraldry and Religion" which chronicles the symbolic impact of butterflies on man in everyday life and in legend is especially noteworthy. The remaining sections delve into those areas which man finds so curiously fascinating: metamorphosis, ornamentation of the wings, the compound eye and protective devices. The section on the wings not only examines the physical aspects in terms of wing scales, pigmentation and wing formation, but also the mechanics involved in temperature regulation and flight, all through the enchanted photographic eye of Kjell Sandved. In "Protective Devices," deception, warning coloration and camouflage are discussed. There is also a brief explanation of Batesian and Müllerian mimicry, along with a discussion of larval specificity on certain toxic hostplants and the important role which these plants play in mimetic associations.

In such a volume which includes an array of photographs, there are some organizational problems in fitting the plates with the appropriate text. The last 25 pages illustrate further intricate designs and structural iridescence, so intriguing to the natural observer. While these are interesting, they seem somewhat superfluous. In a few cases the identifications are incorrect or not in keeping with current literature such as *Thecla syncellus* (= *Panthiades bitis*).

The above points by no means diminish the utility and significance of this book for its intended audience. Its true value will be realized indeed by the enthusiasm and appreciation generated for this diverse biological group in both aspiring and professional lepidopterists alike.

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GENERAL NOTES

OVIPOSITION OF THE BUTTERFLY *BATTUS BELUS* VARUS (PAPILIONIDAE)

Members of the swallowtail genus *Battus* use as larval foodplants woody vines in the family Aristolochiaceae (Brower & Brower 1964, Zoologica 49: 137-159; Ehrlich & Raven 1965, Evolution 18: 586-608; Young 1971, Rev. Biol. Trop. 19: 210-240; Tyler 1975, The Swallowtail Butterflies, Naturegraph, California). The Aristolochiaceae, like many vines, reach their greatest diversity in the New World tropics (Pfeifer 1966, Ann. Missouri Bot. Garden 53: 1-114), where both *Battus* and the closely related *Parides* exploit them. Although the neotropical *B. polydamas* carefully deposits small clusters of eggs on various species of *Aristolochia* in Costa Rica (Young, op. cit.; pers. obs.), the temperate zone *B. philenor* is known to oviposit on plants other than Aristolochiaceae, which are not acceptable to larvae (Tyler, op. cit.). *Parides* always deposits eggs precisely on Aristolochiaceae (Young 1973, Psyche 80: 1-21; 1976, J. Lep. Soc. 31: 100-108). *Battus belus varus* Kollar ranges from Vera Cruz, Mexico to northeastern Ecuador and northern Venezuela (Rothschild & Jordan, 1906,



FIG. 1. *Battus belus varus* ovipositing on *Melothria guadalupensis* (Cucurbitaceae) at Finca La Tigra, near La Virgen de Sarapiquí, Heredia Prov., Costa Rica, 19 February 1977, 1300 hrs.

Novitates Zool. 13: 27–753; Tyler, op. cit.); larval foodplants are various species of *Aristolochia* (e.g., Tyler, op. cit.). This note reports an observation of oviposition of *B. belus varus* on a plant other than a larval foodplant.

On 19 February 1977, a female *B. belus varus* was observed flying among several clumps of woody and herbaceous vines in a secondary forest at Finca La Tigra, near La Virgen de Sarapiquí, Heredia Province, Costa Rica. She finally began ovipositing on a vine, *Melothria guadelupensis* (Spreng.) Cogn. (Cucurbitaceae), intertwined with another vine, *Aristolochia constricta* Griseb.; the leaves of the two plants were similar in size and general shape. Oviposition lasted several minutes (Fig. 1). Forty-three eggs were deposited in a tight cluster on a single leaf of *M. guadelupensis* and no eggs were found on the *A. constricta*. In the laboratory, the freshly hatched larvae did not accept leaves of *M. guadelupensis*, but fed briefly on *A. ringens* Vahl (obtained from H. W. Pfeifer in 1971; locality not specified) before dying. *Aristolochia constricta* was not available for testing.

Tyler (op. cit.) mentions that *B. philenor* accepts only certain species of Aristolochiaceae as foodplants. Foodplant specificity is apparent where different species of *Aristolochia* occur in the same region (Scriber & Feeny 1976, J. Lep. Soc. 30: 70–71). An Australian *Aristolochia*-feeding swallowtail, *Ornithoptera priamus*, has been observed to deposit eggs on an introduced species of *Aristolochia*, and the larvae perished (Straatman 1962, J. Lep. Soc. 16: 99–103). The refusal of *A. ringens*, a plant species native to Costa Rica, by *B. belus* larvae, supports the possibility that *Battus* specializes on restricted larval foodplants within the Aristolochiaceae. Eggs of *B. philenor* have been found on Convolvulaceae and Polygonaceae, vines which generally look like *Aristolochia*. Larvae of another *Aristolochia*-feeding swallowtail, *Polydorus aristolochiae* (Fabricius), have been seen on various Cucurbitaceae in India, but their larvae refused to accept these plants in captivity (Ghosh 1914, Mem. Dept. Agr. India, Entomol. Sec. V(1): 53–587). Only certain species of *Aristolochia* are foodplants of *P. aristolochiae* (Munshi & Moiz 1967, J. Lep. Soc. 21: 127–128). It is possible that *B. belus varus* mistook the cucurbit vine for an *Aristolochia*. Perhaps the very close proximity of the *A. constricta* vine contributed to this confusion, by providing odoriferous and visual properties of a correct foodplant. Alternatively, the oviposition on the intertwined cucurbit might have been deliberate, possibly representing an adaptation to avoid waiting egg parasites and predators. Under this explanation, the newly hatched larvae would have rapidly found the correct foodplant. Further observations are needed to distinguish between these two hypotheses. If an adaptation for avoiding egg parasites and predators, such behavior might be more prevalent among vine-feeding butterflies in the tropics, where the intertwining of unrelated vines is common.

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MALFUNCTION OF ECDYSIS ALLOWING IMAGINAL EMERGENCE BUT CAUSING DEATH OF ADULT HACKBERRY BUTTERFLY (NYMPHALIDAE)

Insects must periodically shed their skins—a process known as ecdysis which allows growth or transformation of the individual. Each molt period is a dangerous time during which the insect is susceptible to predation or physiological malfunctioning, both of which may cause death. Natural selection has, therefore, perfected the process of ecdysis to such a degree that physiological failures are rare. I describe

below the partial failure of an act of ecdysis—a developmental malfunction which did not prevent transformation, but one that was eventually fatal to the butterfly involved. Such malfunctions are not uncommon in laboratory cultures; however, this observation is of interest because it involved a wild-caught adult.

On 17 July 1977 at 1100 hours CDT, I was handed an adult female *Asterocampa celtis antonia* (Edwards) which had been hand-collected in a residential backyard in Austin, Travis County, Texas. Lack of worn spots on the fully expanded wings, occasional release of untransformed fluids and an egg-packed abdomen indicated recent emergence, probably that same morning. I soon discovered that the head was covered with partial exuviae which had not been properly shed. Practically the entire chrysalid head capsule was still present covering the greater part of the imaginal head. Additionally, the left side of the larval head capsule was still attached to the outside of the chrysalid head capsule.

Upon metamorphosis of the prepupa to pupa, the left half of the final-instar larval head capsule failed to separate from the newly formed pupal epidermis. When imaginal emergence occurred, both sides of the pupal "head" failed to separate as a result of mechanical restriction caused by the still-present larval head capsule section.

Although the adult was able to emerge and properly expand and dry its wings, damage to selected parts of the head effectively negated any chance that this individual would reproduce. Both eyes appeared completely normal and allowed reaction to approaching objects. The left antenna was not visible, having been transformed into an unrecognizable mass associated with the remnant exuviae. The right antenna was free and fully developed; however, it was flexed laterally and horizontally (about 75° from perpendicular) about 2 mm from its base. This antenna could be moved at its base, but such movements occurred only when the antenna was touched; no spontaneous movements were observed. The most significant damage affecting the fitness of this individual involved its proboscis. The proboscis was entirely nonfunctional because of failure of the two maxillae to properly fuse. The two halves adhered to each other in a haphazard manner and to the remaining exuviae; removal of the exuviae was accompanied by removal of the proboscis halves.

Lack of a functional proboscis caused early death of this individual, because the butterfly was unable to feed or obtain moisture. This damaged individual grew progressively weaker until it died approximately 75 hours following capture (in a cage at an ambient diurnal temperature range of about 25–35°C). I thank Patrick K. Neck for supplying the specimen.

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AGGREGATIVE BEHAVIOR OF *ANARTIA FATIMA* (NYMPHALIDAE) IN GUANACASTE PROVINCE, COSTA RICA DURING THE DRY SEASON

The neotropical butterfly *Anartia fatima* Fabricius (Nymphalidae: Nymphalinae) is widespread throughout the coastal wet and dry regions of Central America and northern South America (Godman & Salvin 1879, *Biologia Centraliamericana*, Insecta, Lepidoptera-Rhopalocera, vol. 1, 487 p.). Several larval foodplants, in the Acanthaceae, are shared with other nymphalines such as *Siproeta* (Young & Muysmond 1974, *Stud. Neotrop. Fauna* 9: 155–176), but during the severe dry season of dry regions these plants exhibit leaf drop and become unsuitable for oviposition (Young & Stein 1975, *Contr. Biol. & Geol.*, Milwaukee Pub. Museum, No. 8, 29 p.). Several years of observing *A. fatima* populations in the lowland tropical dry forest region (Tosi 1969, Mapa

ecologico de Costa Rica, Trop. Sci. Centr., San José, Costa Rica), Guanacaste Province, indicate that adults are abundant and active throughout the dry season, especially in fields with fully leaved shrubs and trees. This note discusses aggregative behavior of adult *A. fatima* in Guanacaste.

During the afternoon (1530 h) of 26 January 1977, 12 individuals of *A. fatima* were seen fluttering about a low shrub in a field near Playas del Coco. The general area is about 4 km from the Pacific coast and highly exposed to strong gusty winds characteristic during the dry season. Most of these butterflies were worn. Eventually they settled inside the bush for the rest of the day and night. They were scattered in the leeward side of the bush. Most rested, with wings folded, by hanging from shaded branches. This behavior was observed again on 20 February 1977 at Playa Naranjo; six butterflies settled into a shrub at 1615 h remaining there until the following morning. This bush was 400 m from the beach (Gulf of Nicoya) and exposed to strong gusty winds. During the following day, adults fluttered inside the bush, with occasional settling for short periods (1–6 min). At no time were more than one or two butterflies resting at once. Both days were sunny, with air temperature near these bushes being 40–42°C. The air temperature inside them at the same time of day was 32–34°C. *Anartia fatima* was active, along with *Phoebis* (Pieridae), in the surrounding habitat, visiting various flowers. These observations took place during the severe, 4–6 month dry season of this region. The bushes used by *A. fatima* were low and dense with branches and leaves. Strong winds coming from the nearby coast were blocked, as indicated by holding a handkerchief on the lee side of the bushes.

While it is generally well documented that unpalatable butterflies exhibit highly structured communal nocturnal roosting (e.g., Crane 1957, *Zoologica* 42: 135–146; Brower & Brower 1964, *Zoologica* 49: 137–159; Urquart 1960, *The Monarch Butterfly*, Univ. Toronto Press, 361 p.; Owen & Chanter 1969, *J. Zool. (London)* 157: 345–374; Young & Thomason 1975, *J. Lep. Soc.* 29: 243–255), less is known about the nocturnal behaviors of supposedly palatable species. Other nymphalines, such as *Marpesia berania* (Hewitson), *Hypolimnias bolina* Linnaeus, and *Smyrna karwinski* (Geyer), exhibit highly structured nocturnal communal roosting (Barrett & Burns 1951, *Butterflies of Australia and New Guinea*, Seward, Melbourne, 187 p.; Benson & Emmel 1973, *Ecology* 54: 326–335; Muysshondt & Muysshondt 1974, *J. Lep. Soc.* 28: 224–229) although the adaptive role of this behavior has not been determined. The unstructured condition of *A. fatima* aggregates and their low numbers suggests that such behavior is a sheltering and thermoregulatory response to a dry, windy environment. Prevailing high temperatures throughout the day, low air humidity, and strong evening winds induce flocking behavior in *A. fatima*, causing adults to aggregate in some bushes. Low, thick bushes offer protection from the sun and evening gusty winds. On the Pacific slopes of the Cordillera Central in Costa Rica, evening aggregates of another nymphaline, *Siproeta stelenes* Fabricius, are found in coffee bushes during the dry season (pers. ob.); these localities are also exposed to strong, gusty winds and dry conditions.

The presence of worn adults suggests that sites of aggregation are not necessarily located near eclosion sites; both *A. fatima* and *S. stelenes* oviposit singly, and eggs are distributed over large areas, resulting in low densities of adults eclosing at one spot (Young & Stein 1975, op. cit., Young & Muysshondt 1974, op. cit.). On Grand Cayman Island, British West Indies, adults of *Anartia jatrophae* Linnaeus cling to the leeward sides of low clumps of the creeping vine *Clitoria* sp. (Leguminosae) on sunny afternoons in February (pers. obs.).

The aggregative behavior of nymphaline butterflies in exposed secondary habitats near the wind-blown coasts of Caribbean islands and mainland Central America during the dry season could be related to thermoregulation and physical protection from strong winds. The dark brown wing and body color of *A. fatima* and other species such as *S. stelenes* undoubtedly result in considerable heat gain during afternoon

hours; the thermoregulatory problems of *A. fatima* have been discussed (Emmel 1972, Evolution 26: 96-107). Gradual heat gain on sunny days leads to shade-seeking behavior by late afternoon and shady perches also provide nocturnal shelter from winds. It is known that for some insects living in hot climates, such as desert cicadas, gains in body heat result in definite periods of movement into shade and subsequent quiet periods (e.g., Heat & Wilkin 1970, Physiol. Zool. 43: 145-154). Dark butterflies in lowland tropical dry climates may have similar temperature-response problems.

The above observations and comments suggest that aggregative behavior of *A. fatima* is an adaptive response to highly localized climatic or abiotic factors, having little or nothing to do with biotic factors such as vertebrate predators. A biotic result of such behavior, however, may be the maintenance of a cohesive adult population that survives until the following rainy season to oviposit on foodplants as they leaf out. This idea has been discussed with respect to *S. karwinski* (Muyshondt & Muyshondt 1974, op. cit.) and it may be generally true for other secondary habitat or pasture-dwelling tropical nymphalines which pass the dry season in the adult stage.

This fieldwork was funded by N.S.F. Grant GB-33060 and friends of the Museum, Inc. of the Milwaukee Public Museum.

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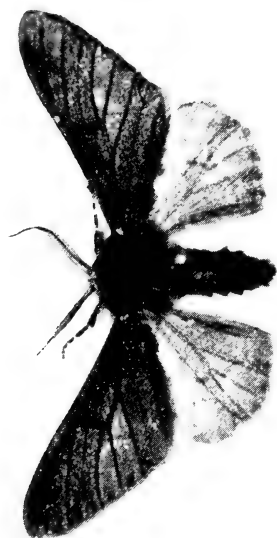
BISTON BETULARIA, OBLIGATE F. INSULARIA INDISTINGUISHABLE FROM F. CARBONARIA (GEOMETRIDAE)

It is well known that there is sometimes difficulty in phenotypically recognizing and scoring f. *insularia* of *Biston betularia*. On the one hand it may be confused with *carbonaria* (Kettlewell 1973, The Evolution of Melanism, Oxford, London) and on the other with "typical," particularly in the Isle of Man (Bailey *et al.* 1973, Entomologist 106: 210-214). To help clarify the matter, various scoring methods have been devised for *insularia*, e.g., that of Lees and Creed (1977, Heredity 39: 66-73, and used by us), where I¹ is the lightest and I³ the darkest. Nevertheless, difficulties remain, and Lees and Creed (1977) report a brood, B/574, in which a mating between two *insularia* I³/"typical" heterozygotes produced 66 "typical," 149 I³ *insularia* and 77 *carbonaria* which were thought to be I³/I³ homozygotes. They also quote Bowater (1914, J. Genet. 3: 299-315) who crossed a wild *carbonaria* male with a "typical" female, and all the resulting progeny were dark *insularia*, which is consistent with the I³/I³ hypothesis.

The present note shows that this cannot always be the explanation since the brood to be described could not have produced I³/I³ homozygotes. On 13 June 1976 a female "typical" (Fig. 1a) was caught in a mercury vapor trap on Hilbre Island near West Kirby, Wirral, England. She was placed in a tin for the following five nights and laid a few eggs, but these were infertile. On the night of 19 June 1976, she was put in a hanging cage with a male *insularia* (Fig. 1b) (score I³, confirmed by Lees and Creed, pers. comm.), which had been caught in the mercury vapor trap at Caldy, Wirral. Mating took place the same evening and the female then laid freely (brood 14672). After she died on 28 June 1976 her body was found to contain a single spermatophore only.

TABLE 1. The 1977 matings from brood 14672. All "dark" insects were indistinguishable from *carbonaria* except where stated (see brood 15090).

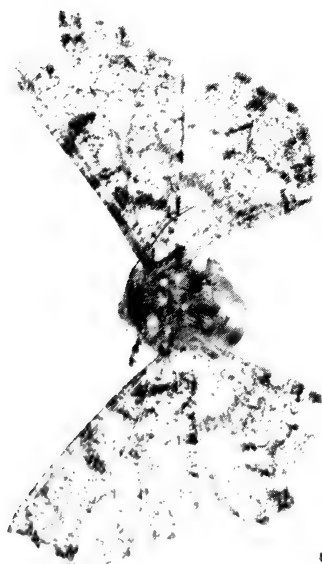
Brood number	Form and brood of P ₁ ♀	Form of provenance of P ₁ ♂	Offspring				Comments
			♂ ♂		♀ ♀		
			"typical"	"dark"	"typical"	"dark"	
15086	<i>insularia</i> 14672	"typical" 14672	7	5	5	5	Sib mating, but backcross qua "typical"
15087	<i>insularia</i> 14672	"typical" wild, Caldý, Wirral	114	96	100	100	Backcross to "typical"
15088	<i>insularia</i> 14672	<i>insularia</i> 14672 (sib)	21	51	15	47	Sib mating of two heterozygotes
15089	<i>insularia</i> 14672	"typical" 14672 (sib)	31	38	33	49	Sib mating, but backcross qua "typical"; ratio "dark"/"typical," not significantly different from 1:1
15090	<i>insularia</i> 14672	"typical" 14672 (sib)	48	47	44	49	Sib mating, but backcross qua "typical"; one "dark" ♂ and one "dark" ♀, clearly I ³
15097	<i>insularia</i> 14672	<i>carbonaria</i> wild, Caldý, Wirral	2	9	7	12	Mating of two insects both heterozygous for "typical"
15098	<i>insularia</i> 14672	"typical" wild, Hoylake, Wirral	24	23	18	34	Backcross to "typical"
15107	<i>insularia</i> 14672	"typical" wild, North Wales	32	24	26	27	Backcross to "typical"



2a



2b

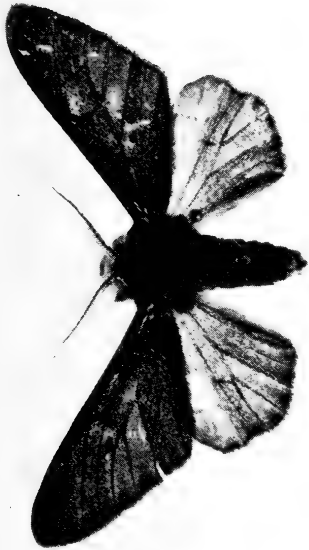


1a

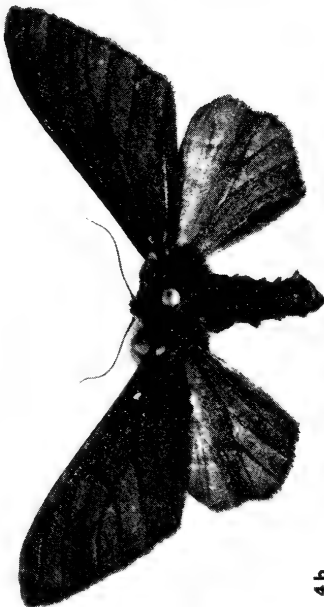


1b

FIGS. 1-2. *Biston betularia*. 1a. ♀ "typical," parent brood 14672; 1b. ♀ *insularia*, I³, of brood 14672. 2a. ♂ *insularia*, I³, parent of brood 14672; 2b. ♂ *insularia*, I³, of brood 14672.



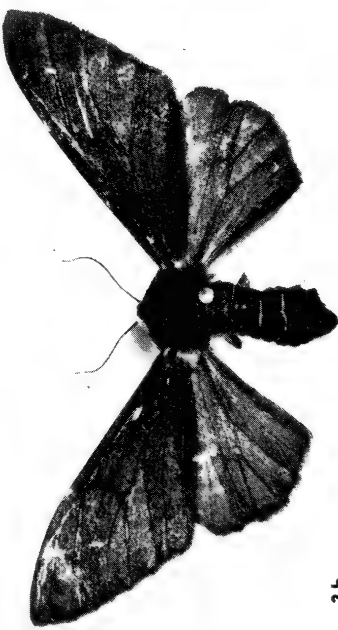
3a



4a



3b



4b

FIGS. 3-4. *Biston betularia*. 3a, ♂ *carbonaria*, M.V. trap-caught, 1977 Caldý; 3b, ♀ *carbonaria*, M.V. trap-caught Caldý; 4a, ♂ *insularia* of brood 14672, indistinguishable from *carbonaria*; 4b, ♀ *insularia* of brood 14672, indistinguishable from *carbonaria*.

Brood 14672 produced 394 insects, the moths emerging between May and July 1977. There was clear-cut segregation between "typical" (90 ♂♂; 97 ♀♀) and "dark" (100 ♂♂; 107 ♀♀).

Since *carbonaria* is dominant to *insularia*, and "typical" is recessive to both, and because the brood segregated in a 1:1 ratio, "typical" to "dark," the male parent must have been *insularia*/"typical" and the "dark" offspring must all have been *insularia*/"typical" heterozygotes.

We found great difficulty in scoring the brood. Some of the *insularia* males undoubtedly had a sparse scattering of white scales and rather light hindwings (Fig. 2a), but they lacked the white scales on the thorax or abdomen characteristic of *insularia*. Others appeared to us to be quite indistinguishable from *carbonaria* and we cannot agree that the two can easily be separated, "... since in *carbonaria*, when the white scales are present on the forewing, they are distributed to form a thin, unbroken transverse line across the middle of the forewing" (Steward 1977, Ecol. Entomol. 2: 231-243). The *insularia* females in brood 14672 (Fig. 2b) present even more of a problem, because they are normally darker than the males and we should have scored nearly all of them as *carbonaria* (Figs. 3b and 4b).

We appreciate that in expert hands specimens may be scored more competently, but had the "dark" males of brood 14672 been "trap caught" (Fig. 3a), we (and we think others) would have scored many of them (see Fig. 4a) as "*carbonaria*," and Creed (pers. comm.) agrees with this view.

Kettlewell (1973, The Evolution of Melanism, Oxford, London) thinks that those *insularia* which are difficult to distinguish from *carbonaria* are in a minority, as are the pale *insularia* misclassified as dark "typical." He further thinks that because of the small numbers in these two categories, the frequency figures for "typical" and *insularia* are largely unaffected. However, it is difficult to be sure of this since we do not know how often misscoring takes place, and different observers in the same locality do, in fact, obtain very different results when recording the frequency of the three forms (see Kettlewell, 1973, op. cit., table 9: 2).

Creed (pers. comm.) thinks that *carbonaria* as scored in the wild is perhaps as heterogeneous as *insularia*. We agree with this, and feel that the possibility of misscoring of males should be seriously considered when unusual frequencies of *carbonaria* and *insularia* are reported. (The misscoring of females is much less important as they rarely come to mercury vapor light and never to an assembly trap.)

Sib matings and backcrosses using brood 14672 were set up and their results are given in Table 1. Moths which were obligatory *insularia*/"typical" heterozygotes again were almost always indistinguishable from wild-caught *carbonaria*, as were *insularia*/*carbonaria* heterozygotes. Furthermore, there was no detectable difference between any of these "dark" insects and those in brood 15088, which must have contained *insularia* homozygotes. An additional mating was set up from this stock in 1978 using the *insularia* female (I³) from brood 15090. These results will be reported later.

We are grateful to the late Dr. E. R. Creed and to Dr. D. R. Lees for scoring a sample of our brood and for their helpful comments, and to the Nuffield Foundation, The Royal Society and the Science Research Council for continued support.

Note added in proof: Brood 15490 using this female I³ mated to a male "typical" is segregating (so far) cleanly I³ and "typical" with no *carbonaria*.

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BROTHER APOLINAR MARIA (1867-1949) AND HIS CONTRIBUTIONS TO COLOMBIAN LEPIDOPTEROLOGY

Brother Apolinar María (né Nicholas Seiler) is an all but forgotten name in the annals of South American Lepidopterology. Nevertheless, he built up the largest collection of butterflies in Colombia. He published several papers on Lepidoptera and described a number of new taxa. He sent countless Colombian specimens to several institutions and private collections in the Americas and Europe. This note gives an account of his life and deeds, and the butterfly taxa he described.

Brother Apolinar María was born on November 5th, 1867 in Sarreguemines, Alsace, France. He lived for some time in Reims, and possibly it was here that he joined the religious Brotherhood of La Salle. He was sent by his superior to Colombia, where he arrived in 1904 on the S.S. "León XIII."

A few years later (in 1912) he founded the Natural History Society of the La Salle Institute in Bogotá, with the enthusiastic help of some local amateur naturalists, several of whom had been his own pupils. The Society published the first number of its periodical in 1913, and it went on uninterruptedly until 1931, when it stopped publication after 110 numbers.

In its pages, Brother Apolinar, his colleagues, pupils and friends published numerous observations on Colombian natural history. Among short notes and some longer papers, Brother Apolinar made 75 contributions on Colombian butterflies.¹

Through numerous correspondents in many regions of Colombia, Brother Apolinar received large numbers of natural history objects, which were used by him to enrich the holdings of the Natural History Museum. This museum had become by far the most important natural history institution of Colombia at that time. By 1930, the Lepidoptera collection included 17,235 specimens.

Many butterfly specimens also were sent to friends in America and Europe. Among his many correspondents were C. Oberthür, A. H. Fassl, W. Schaus, H. G. Dyar and R. F. d'Almeida. Later, Apolinar was elected an honorary life member of the Colombian Academy of Exact, Physical and Natural Sciences.

In 1948 he received the severest blow in his long scientific career. On April 9th and 10th rioting and plundering parties set fire to, and destroyed, a great number of public and private buildings in downtown Bogotá. The library and the collections of the La Salle Natural History Museum were irretrievably lost (cf. Dugand 1948, *Caldasia* 5(22): 223; LeMoult 1948, *Misc. Entomol.* 45: 93; Remington & Remington 1948, *Lepid. News* 2: 61; Ruiz 1950, *Rev. Acad. Colomb. Cienc. Exact. Fis. Nat.* 7(28): 433; and Daniel 1950, *Bol. Soc. Cienc. Nat. Caldas* 51: 74). Apolinar died on December 24th, 1949.

Between 1914 and 1942 Brother Apolinar described 42 butterfly taxa. Several of those taxa have never been recorded in the *Zoological Record* (nor by Beattie 1976, *Rhopalocera Directory*). In spite of the rather naïve form of his taxonomic descriptions, they are nevertheless valid, and his names are available in most cases, so that they should be accepted as representing valid taxa. Unfortunately, his descriptions are usually quite vague. In most instances no figures were provided, and all of his types were lost in the 1948 fire.

LIST OF BUTTERFLY TAXA DESCRIBED BY BROTHER APOLINAR MARÍA

BLS = Boletín de la Sociedad de Ciencias Naturales del Instituto de La Salle;
BSC = Boletín de la Sociedad Colombiana de Ciencias Naturales; RSC = Revista de la Sociedad Colombiana de Ciencias Naturales; RAC = Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales.

¹ A bibliography of Apolinar's publications on Colombian butterflies is available from the author upon request.

PAPILIONIDAE

- Papilio isidorus* var. *lelargei*; BLS, 1915, 3(9): 142 (Susumuco, Colombia) [Holotype; sex not stated] ["lelargei" is a typographical error for "lelargei"].
- Papilio oberthuri*; BLS, 1916, 4(27): 32 (Quebrada Negra, El Baldío, Colombia) [Holotype; sex not stated].
- Papilio euryleon abadiae*; BLS, 1916, 4(31): 95 (Muzo, Colombia) [Holotype; sex not stated].
- Papilio rhodostictus nymphius* "orientalis"; BSC, 1924, 13(76): 108 ("Llanos," Villavicencio, Medina, etc., eastern Colombia) [14 ♂♂ syntypes].
- Papilio rhodostictus nymphius* "occidentalis"; BSC, 1924, 13(76): 108 (Muzo, Colombia) [5 ♂♂, 1 ♀, syntypes].

PIERIDAE

- Colias dimera mariae*; BLS, 1914, 2(1): 17 (Serranía de Monserrate, Páramo de Choachí, Colombia, 2900 m, 2.i.14) [Holotype; sex not stated].
- Colias dimera* var. *fassli*; BLS, 1914, 2(1): 17 (Páramo de Choachí, Colombia) [several ♂ and ♀ syntypes; figured in RAC, 1942, 5(17): pl. [1], figs. 9–10].
- Nathalis plauta* var. *nigrescens*; BLS, 1914, 2(2): 45 (San Cristóbal, Colombia, 31.xii.13) [Holotype ♀].
- Nathalis plauta* var. *xanthoptera*; BLS, 1914, 2(10): 304 (neighborhood of Bogotá, Colombia) [several ♀ syntypes].
- Perrhybris pandora* ab. "teresa"; BSC, 1926, 15(84): 15 (Villavicencio, Colombia) [Holotype ♀; figured as *P. p.* var. *teresa* in RAC, 1942, 5(17): pl. [1], fig. 4].
- Perrhybris lypera* ab. "mariae"; RSC, 1930, 4(105): 59 (Muzo, Colombia) [two ♀ syntypes; figured in RAC, 1942, 5(17): pl. [1], fig. 3].
- Pereute leucodrosime* ab. "mariae"; BSC, 1926, 15(84): 17 (Villavicencio, Colombia) [Holotype ♀; figured as *P. l.* var. *mariae* in RAC, 1942, 5(17): pl. [1], fig. 5].
- Catasticta uricoecheae bouvieri*; BSC, 1926, 15(84): 24 (Chocó, Colombia) [Holotype; sex not stated; figured as *C. bouvieri* in RAC, 1942, 5(17): pl. [1], fig. 8].
- Daptonoura calymnia* ab. "leucoptera"; BSC, 1926, 15(85): 43 (Las Mesitas, Fusagasugá, Colombia) [two syntypes; sex not stated].
- Daptonoura polhymnia flavopunctata*; BSC, 1926, 15(85): 44 (Muzo, Colombia) [4 syntypes; sex not stated].
- Teria* [sic] *mexicana henrici*; BSC, 1926, 15(85): 46 (Sonsón, Colombia) [3 ♂♂, 2 ♀♀, syntypes].
- Teria* [sic] *gaugamela alba*; BSC, 1926, 15(85): 47 (Medellín, Colombia) [Holotype ♀].
- Dismorphia acutipennis llerasi*; BSC, 1926, 15(86): 96 (Llanos de Guacaramo, Colombia) [Holotype; sex not stated; figured in RAC, 1942, 5(17): pl. [1], fig. 6].
- Dismorphia arcadia* ab. "melanoptera"; BSC, 1926, 15(86): 99 (Villavicencio; Pensilvania, Caldas, Colombia) [1 ♂, 1 ♀, syntypes].
- Dismorphia demeter confluens*; BSC, 1926, 15(86): 100 (Vergara or Choachí, Colombia) [Holotype; sex not stated].

NYMPHALIDAE

SATYRINAE

- Idioneura erebioides* f. *intermedia*; BLS, 1914, 2(2): 46 (no locality) [several syntypes; sex not stated].
- Lymanopoda samius* var. *nigripunctata*; BLS, 1914, 2(2): 47 (no locality) [Holotype; sex not stated].
- Lymanopoda samius* var. *confluens*; BLS, 1914, 2(2): 48 (no locality) [several syntypes; sex not stated].
- Pedaliodes nebris albipunctata*; BLS, 1914, 2(3): 76 (Páramo de Choachí, Colombia, 3100 m) [Holotype; sex not stated].

- Pedaliodes nebris athymi*; BLS, 1914, 2(3): 76 (Páramo de Choachí, Colombia, 3100 m) [15 syntypes; sex not stated].
- Pedaliodes nebris conchae*; BLS, 1914, 2(3): 77 (Páramo de Choachí, Colombia, 3100 m) [10 syntypes; sex not stated].
- Pedaliodes nebris* var. *abadiae*; BLS, 1914, 2(3): 77 (Páramo de Choachí, Colombia, 3100 m) [3 syntypes; sex not stated].
- Pedaliodes nebris* var. *pauli*; BLS, 1914, 2(3): 77 (Páramo de Choachí, Colombia, 3100 m) [10 syntypes; sex not stated].
- Pedaliodes nebris* var. *tripunctata*; BLS, 1914, 2(3): 77 (Páramo de Choachí, Colombia, 3100 m) [several syntypes; sex not stated].
- Pedaliodes nebris* var. *modesta*; BLS, 1914, 2(3): 77 (Páramo de Choachí, Colombia, 3100 m) [Holotype; sex not stated].
- Pedaliodes nebris estanislaoi*; BLS, 1914, 2(3): 78 (Páramo de Choachí, Colombia, 3100 m). [Holotype; sex not stated].
- Zapatoca*; BSC, 1924, 13(76): 84. Unjustified emendation of *Sabatoga* Staudinger, 1897. *Invalid*.
- Zapatoca* [sic] *viventieni*; BSC, 1924, 13(76): 84 (Guasca, Colombia) [Holotype; sex not stated].

MORPHINAE

- Morpho amathonte* var. *nigromarginata*; RAC, 1942, 5(17): pl. [1], fig. 2 (no locality) [Holotype ♂].

ITHOMIINAE

- Mechanitis egaensis septentrionalis*; BSC, 1928, 17(98): 164, 180 (Valle de Tensa, Garagoa, Boyacá, Colombia) [Holotype; sex not stated].

HELICONIINAE

- Heliconius ismenius abadiae*; BSC, 1926, 15(87): 125 (no locality) [3 syntypes; sex not stated].
- Heliconius cydno hermogenes* ab. "xanthosticta"; BSC, 1926, 15(88): 153 (Valle del Cauca, Colombia) [11 syntypes; sex not stated].
- Heliconius cydno hermogenes* ab. "leucosticta"; BSC, 1926, 15(88): 153 (Valle del Cauca, Colombia) [19 syntypes; sex not stated].
- Heliconius cydno dolores*; BSC, 1926, 15(88): 155 (Tolima, Colombia) [Holotype; sex not stated].
- Heliconius aristiona colombiana*; BSC, 1927, 16(92): 117 (Susumuco, Colombia) [Holotype; sex not stated].
- Heliconius mixta*; BSC, 1927, 16(92): 119 (Llanos de Medina, Guaicaramo, Colombia) [Holotype; sex not stated].

NYMPHALINAE

- Callicore astala* var. *coeruleomarginata*; BSC, 1928, 17(98): 164, 183 (Río Putumayo, Colombia) [Holotype; sex not stated].

WEATHER AND THE REGULATION OF *HYPOTHYRIS EUCLEA*
(NYMPHALIDAE): POPULATIONS IN NORTHEASTERN COSTA RICA

Brown and Neto (1976, *Biotropica* 8: 136-141) found that populations of some ithomiine butterflies (*Hypothyris* and *Mechanitis*) in Brazil are controlled largely by parasitism of eggs and larvae during the wet season. Presumably periods of increased daily precipitation provide increased opportunities for successful parasitic attacks. Characteristically, local adult populations of *Mechanitis* and *Hypothyris* exhibit large fluctuations in numbers throughout the year (Brown & Neto, op. cit.; pers. obs.).

Populations of *Hypothyris euclea leucania* (Bates) exhibit annual periods of sudden, rapid growth of adult populations in northeastern Costa Rica (Young 1977, *Pan-Pacif. Entomol.* 53: 104-113). It was presumed in that study that the frequency of mating and oviposition and the survival of eggs and larvae were increased during a period of dryness preceding the time of increased population abundance. The purpose of this note is to present further data on *H. euclea* that support my earlier prediction that greatly increased adult numbers, in northeastern Costa Rica, follow dry periods.

At times each year (1971-77), at Finca La Tirimbina, La Virgen, Heredia Province (220 m elev.), very high density concentrations of adult *H. euclea* occur along forest trails and clearing. At these times, many individuals of the larval foodplant, *Solanum rugosum* Dund. (Solanaceae), are heavily defoliated by *H. euclea* larvae feeding a few weeks earlier. Few larvae are present during weeks of high adult abundance. The deposition of many large egg masses on *S. rugosum* results in many larvae and defoliation (Young, op. cit.). Walking along a forest trail flushes out many resting butterflies; from one to 30 adults may be flushed from a five-meter section of trail on a sunny day. Most of these are fresh. At other times of the year, as few as one or two adults occur in about 100 meters of trail. Sometimes adults are conspicuously absent. Adults feed on dead insects and fresh bird droppings. Either adult dispersal or mortality is high over short periods (one week) since, for example, from 40 fresh adults marked during a 20-minute period one day (15 August 1977) at

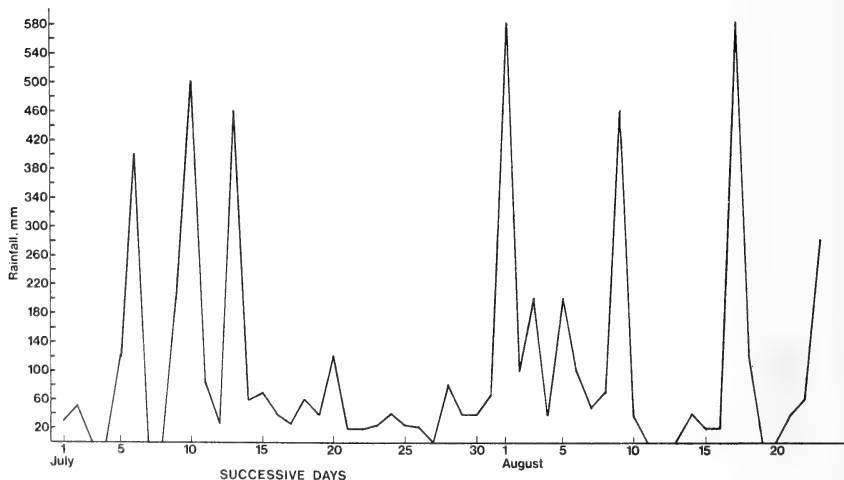


FIG. 1. Daily rainfall levels for July and August 1977 at Finca La Tirimbina, La Virgen de Sarapiquí. Note the two-week dry period in the latter part of July. Data courtesy Dr. J. Robert Hunter.

one spot, only three were recaptured two days later and none a week later. Two-thirds of these butterflies were males. A few weeks later, adult numbers had declined considerably at five different spots where abundances were very high for at least three weeks. Brown and Neto (op. cit.) found that populations of *H. euclea* and *H. daeta* diminish rapidly in size as a result of high dispersal and high longevity of adults. If July–August 1977 is used as an example, August was characterized by heavy daily downpours, both day and night, but this rainy period was preceded by a dry period during the last two weeks of July (Fig. 1).

The life cycle of *H. euclea* at this locality takes about 22 days (Young, op. cit.). Thus frequent deposition of large egg masses at this locality and high survival of eggs and larvae result in a large wave of fresh adults about three weeks later. For example, egg masses deposited during the dry period in July 1977 produced the large adult population present in August. Mortality factors operative on egg rafts and gregarious young larvae may be drastically reduced in frequency and intensity during periods of dry weather (Young, op. cit.). Although the proximal causes of this apparent mortality are unknown, their activity correlates well with wet periods. A broad range of invertebrate predators and pathogenic fungi are very likely involved in the regulation of *H. euclea* populations. Gilbert (1969, Some aspects of the ecology and community structure of ithomiid butterflies in Costa Rica, Organization for Tropical Studies, mimeo report) found ants and wasps to be predators of *H. euclea* larvae. Gilbert also suggests that egg mortality from leaf-patrolling predators is operative in *H. euclea* populations. Waves of pupal and adult flour beetles (*Tribolium* spp.) follow periods of slackened predation (Mertz 1969, Ecol. Mongr. 39: 1–31. Dry weather may also enhance mating and oviposition (Young, op. cit.), thereby “stacking the deck” even further for a large cohort of adults to appear.

These observations suggest that tropical butterfly populations subject to control or regulation by biotic agents may be, in fact, regulated only to the extent to which daily rainfall patterns influence the activity of these agents.

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Journal of the Lepidopterists' Society
33(1), 1979, 69–71

BOOK REVIEW

PENNINGTON'S BUTTERFLIES OF SOUTHERN AFRICA, edited by C. G. C. Dickson with D. M. Kroon, 1978. Ad. Donker, Johannesburg and London. 671 pp., including frontispiece, 198 plates, 1 text figure and 1 map. Price: R49.00 (approximately \$80.00 U.S.).

The manuscript for this book was begun many years ago by K. M. Pennington, but “KMP” never lived to see its appearance. It is a testimony to the heartfelt admiration that his fellow collectors felt toward Pennington that they were determined that KMP's life work would not go unpublished. For the next three years Mr. Dickson and Dr. Kroon revised, updated and added to the manuscript to make it ready for publication. They have done an admirable job and produced in Pennington's honor a truly outstanding book, one that is not duplicated by other regional treatments of a comparably sized fauna.

The 781 species of butterflies found in southern Africa (including South Africa, Southwest Africa and much of adjacent Rhodesia and Mozambique) are treated in the text on pages 33–201. This is a fauna comparable to the rhopaloceran fauna oc-

curing in the United States and Canada. The treatment includes information on where, when and in what habitats one may find any South African butterfly. Original descriptions are cited meticulously and accurately for all species and many of their synonyms—I only wish in a couple of instances that the editors had used the senior title for works (such as *Die Grossschmetterlinge der Erde* instead of the later translation *The Macrolepidoptera of the World* by Seitz, and *De Uitlandsche Kapellen* . . . rather than *Papillons Exotiques* . . . for Cramer), though in both of these instances footnotes show that the editors accepted the correctness of the original titles but were using those customarily employed in past English language publications.

The plates are excellent, very informative and of the highest technical quality. Using them to identify a South African butterfly is a joy compared with the aggravations the reader is faced with in some recent major books on other faunas. The illustrations in this book, along with those in the equally wonderful *Butterflies of Japan* (T. Fujioka, 1975) are the best advertisements for using quality colored *photographic* plates that I can imagine. There is no possibility of confusing similar species (assuming that superficial characters will distinguish them) by use of these plates and the accompanying text. I might have preferred to see the backgrounds a bit paler blue, but this is just a personal complaint; in no way do the backgrounds detract from the plates' usefulness.

Dr. Kroon's list of the foodplants of South African butterflies (pages 604–643) is a fine and useful compilation of what is known about the life cycles of the region's Rhopalocera. The introductory portion (pages 22–30) by Mr. Dickson show that the South African collectors are far more interested in life histories than are we in this country, and one suspects that they are near the top of the world in awareness of this aspect of lepidopterology.

In any event, the text and plates combined make the identification of any South African butterfly at least possible, something that could not have been said before the publication of the present book.

But no book is perfect, as the editors would be the first to admit, and this one is no exception. Very few typographical errors or mistaken facts have crept into these pages, but the editors might profitably have looked to this side of the Atlantic for some higher classificatory schemes. Munroe's papilionid, Klots' pierid and my satyrid higher classifications are not mentioned, much less used; some relationships could have been elucidated had they been. Fox demonstrated rather well that *Sallya* (= *Crenis* of authors) is really only a glorified *Eunica*, at least the *boisduvali* complex is, but since this work was not cited, the conclusions were apparently not seen. More surprising, though, is the use of *Meneris* instead of *Aeropetes* for the spectacular satyrid *A. tulbaghia* (Linné). That generic synonymy was pointed out years ago by Hemming who resurrected Billberg's 1820 work from obscurity, thus correctly replacing some well-known generic names with Billbergian ones.

The plates, excellent as they are, have not totally escaped the inevitable "glitches." Plate 76 is especially affected since wet and dry season forms are uniformly mixed and Figure 146.ix is of a dry season individual, but this fact is not noted.

Most of the specimens illustrated are in the collection of the Transvaal Museum in Pretoria, but a few are taken from material in other museum and private collections. All sources are cited in the captions. The figure numbers are cross-referenced to the running catalog of the species in the text. This makes finding the text material referred to by the plates very easy, and it also gives an idea of how many of each species are figured. For example, there are 15 specimens of *Charaxes zoolina zoolina* (species 146 in the text) figured, and they are marked by figure numbers 146i to 146xv on the plates. On the occasions that additional specimens are figured out of sequence, this fact is noted where the specimen might have been expected, so the gynandromorph of *Colotis ione* (species 606) is figured on Plate 196 as figure 606xxv, but it is cross-referenced on Plate 150 where it logically would have been placed. Parenthetically, the symbol used in this book for a gynandromorph (♂) is that tra-

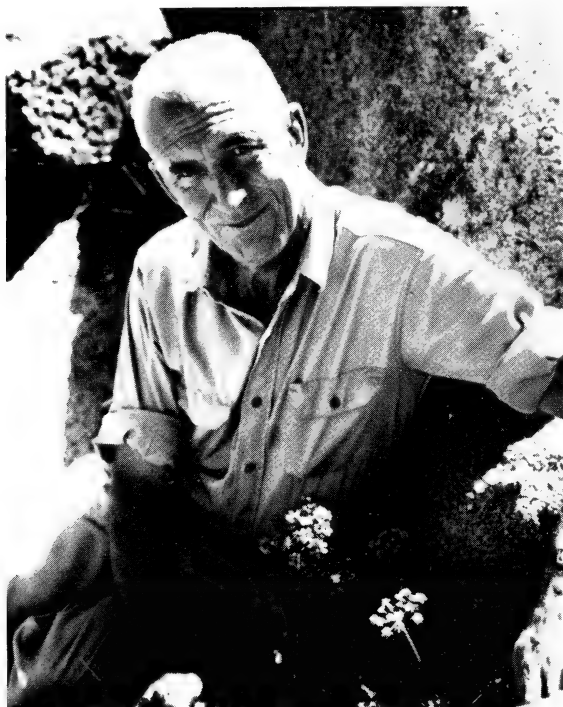
ditionally used for a worker caste of a social insect, rather than the usual ♂ employed for these oddities. The fact that so many examples are figured in variable species enables one to see at a glance the expected variation—a further aid in identification.

The first 38 plates are taken from the late G. C. Clark's incomparable life history studies, encompassing the cycles of 37 species (there are two of *Borbo fatuellus* from different populations) of HesperIIDae. They are of the same quality and in the same style as his earlier plates on the Papilionoidea of South Africa, and Clark, too, has left an impressive legacy to future lepidopterists.

The shortcomings pointed to here in no way diminish the value of this book. It is a major accomplishment, and one that has quickly changed working with South African butterflies from one of the least, to one of the most, possible tasks. Everyone connected with this book—Mr. Dickson, Dr. Kroon, the Trustees of the Ken Pennington's Butterflies of Southern Africa Trust and the printer—are to be congratulated on producing a magnificent major work. I think that K. M. Pennington would be proud of it!

LEE D. MILLER, *Allyn Museum of Entomology, 3701 Bay Shore Rd., Sarasota, Florida 33580.*

OBITUARY



CHRISTOPHER HENNE (1905-1977)

The world of lepidopterology lost a great friend and lepidopterist when Christopher Henne, a long time member of the Lepidopterists' Society, passed away on October 8, 1977.

Henne was born in Denver, Colorado, on July 20, 1905, and at 18 months of age he and his parents moved to California. He grew up in Pasadena where he attended the Polytechnic Elementary School and the Pasadena Military Academy. In 1920, he went to Europe with his mother and spent two years in an English preparatory school in Switzerland. At the age of 17, he returned to the United States and finished his schooling at the Asheville School in Asheville, North Carolina. He then returned to southern California where he was to reside the rest of his life.

He was self-taught as far as his background in entomology was concerned, for he had never even had a course in general biology. He worked in a variety of entomologically related positions, including display preparation and teaching at the Los Angeles County Museum, later followed by the establishment of his own business, Henne Biological Supply, in which he practiced plastic embedding of insects for educational institutions.

In 1961, Chris and his wife Dorothy moved to a new home at the edge of the Mojave Desert in Pearblossom, California, where they retired to full-time collecting. During the next 16 years, his collection was to more than quadruple in size.

Henne's collecting started at age four when the family gardener gave him a *Cecropia* Moth for Christmas. This stimulated a lifelong interest and specialization in moths and butterflies. He soon drove his parents to distraction by his habit of removing the bathroom window screen at night and using the bathroom as a giant light trap for the local moths. As a teenager in Switzerland, he met his first professional lepidopterist, an Englishman, who took him on collecting trips.

After leaving Asheville and returning to Pasadena, Henne was to become one of the most diligent and thorough explorers of the southern California deserts and mountains, collecting in company with most of the noted California lepidopterists of the next five decades. Among his companions during these years of many exciting lepidopterological discoveries were John Adams Comstock, Charles M. Dammers, Jean Gunder, Charles Ingham, Lloyd Martin, C. N. Rudkin, and Munroe Walton. Collecting companions and visitors to his home in recent years included numerous members of the Pacific Slope Section of the Lepidopterists' Society. One could rarely drop in on the Hennes in their Pearblossom home without running into another lepidopterist enjoying their hospitality in the form of "Hennes-on-the-Rocks" (a rum and limeade drink) or "Entomological Goop" (a Noodles Romanoff concoction of shrimp, mushrooms and pimentoes).

Henne's first love was desert collecting and it was in the far reaches of the Colorado and Mojave deserts that he made his most interesting discoveries in Lepidoptera. He was one of the first collectors to investigate the Providence and New York Mountains, and he continued to make field trips to these desert ranges up to the time of his death. In the region around Pearblossom, he studied the biology of numerous butterfly and moth species, recording an immense quantity of information about their foodplants and life histories.

In collaboration with his good friend John Comstock, he worked out many hitherto unknown life histories. Henne collected this material, obtaining ova, larvae, and pupae, and sent it to Comstock who then prepared paintings and descriptions for joint publication. With Comstock's death in 1970, this partnership ceased, but Henne continued to amass data which will be valuable to current and future workers studying the California butterfly and moth faunas. Much of this information is recorded on the very detailed specimen labels on pinned adults in his collection.

He was particularly interested in diurnal moths, and this is reflected in the rich representation of diurnal species of Pyralidae, Ctenuchidae, Sesiidae, and Noctuidae in his collection. In this last family, he took a special interest in the genus *Annaphila*, of which he collected or reared large series of most of the California species. The plume moths (Pterophoridae) were another favorite of his, as evidenced by hundreds of specimens in his collection, many of which were reared.

One of his greatest entomological finds was the rediscovery of the day-flying sphingid, *Euproserpinus euterpe* Henry Edwards, formerly known from only a handful of specimens collected some 90 years ago. He collected a series of specimens while establishing the habitat and foodplant of this rare species.

He named two species, one subspecies (with Comstock), and one form of Lepidoptera, as follows: *Callophrys comstocki* Henne (Lycaenidae); *Copicucullia mcdunnoughi* Henne (Noctuidae); *Philotes enoptes dammersi* Comstock & Henne (Lycaenidae); and *Leptotes marina* form "burdicki" Henne (Lycaenidae). Insects named after him are: *Euphydryas chalcedona quino* transition form "hennei" Gunder (Nymphalidae); *Speyeria coronis hennei* (Gunder) (Nymphalidae); *Penstemonia hennei* Engelhardt (Sesiidae); *Abagrotis hennei* Buckett (Noctuidae); *Annaphila (Proannaphila) hennei* Rindge & Smith (Noctuidae); *Racheospila hennei* Sperry (Geometridae) (NOW *Nemoria obliqua hennei* (Sperry)); *Eucosma hennei* Clarke (Tortricidae); and *Cophura hennei* Wilcox (Diptera: Asilidae).

The Henne collection was purchased in December 1977, by the Los Angeles County Museum of Natural History Foundation. It consists of 36,896 specimens, of which approximately 88% are moths and 12% are butterflies. In the moths, the families

Noctuidae and Geometridae are best represented, along with relatively large numbers of Pterophoridae, diurnal Pyralidae, Ctenuchidae, and Sesiidae. In the butterflies, the genera *Apodemia*, *Philotes* s.l., and *Euphydryas* are particularly well represented. Each specimen is receiving an accession label and is being incorporated into the general collection of the museum, where all will be available for examination and study.

Next to Lepidoptera, Henne loved animals, especially dogs. Two of his pet dogs were orphans he found on collecting trips. He also had a keen interest in automobiles, and frequented car shows and races throughout southern California. Pursuing two hobbies simultaneously, his early trips over primitive desert roads to the famous Bonanza King Mine area of the Providence Mountains were made in a prized 1934 Auburn Speedster.

His inventive mind developed a number of novel techniques for rearing in his Pearblossom laboratory. One of the spin-offs was the development of the Henne Clothes-Moth Trap. He also developed techniques in the field of plastic embedding which retained the natural color and shape of the insects used.

In everything he did, whether rearing larvae or spreading adult specimens, Chris Henne was a perfectionist. His collection of immaculately curated material, with incredibly detailed data, is as aesthetically pleasing as it is scientifically valuable. Anyone who sees this collection will immediately appreciate the copious time and effort put into it by one of California's most prolific and gifted lepidopterists. He will be greatly missed by all who had the privilege and pleasure of knowing him.

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JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



20 July 1979

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Cover illustration: Third instar larva of *Limenitis archippus* Cramer (Nymphalidae) preparing to enter winter diapause. The larva is resting on the lip of its hibernaculum constructed from the basal portion of a chewed tubular willow leaf (*Salix babylonica* Linnaeus) covered with silk. In the autumn such larvae begin facultative diapause in response to decreasing day-length. Original drawing by Mr. George C. Ford, Jr., Graphics Illustrator, Department of Biological Sciences, University of Maryland Baltimore County, 5401 Wilkens Avenue, Catonsville, Maryland 21228.

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 33

1979

Number 2

Journal of the Lepidopterists' Society
33(2), 1979, 77-111

SUBSPECIFIC VARIATION IN BUTTERFLIES: ADAPTATION AND DISSECTED POLYMORPHISM IN *PIERIS* (*ARTOGEIA*) (PIERIDAE)

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ABSTRACT. Subspecific variation of butterflies has in the past been attributed (with doubtful justification) to local ecological factors. In part I of this paper, main types of variation in wing-color and marking in the *Artogeia napi-bryoniae-melete* group are described. Genetic control is relatively simple and known phenocopies result from environmental abnormalities unrelated to any actual local conditions.

In part II, selective agents are considered to exercise little or no control over sub-specific pattern-differences. Physiological adaptation is certain, but visible characters appear not to be specially adapted to present local conditions.

In part III, the extreme selectionist position is rejected. Phenotypic differences have arisen historically, often in consequence of the dissection of polymorphisms, and are maintained by the succession of genetic path-choices in effectively isolated populations. Territorial changes have involved the retention of pattern-elements in biotopes far removed, geographically and ecologically, from the places of origin. Common possession of even superficial characters, when genetically identical, implies phylogenetic relationship.

Some consequences of range-changes of populations are discussed.

In this paper it will be maintained that wing-pattern (and other phenotypic) variation among subspecies of butterflies is generally controlled not by present ecology but by factors having an historical aspect. Arguments will be related particularly to the group *Artogeia napi* + *bryoniae* + *melete*. The genus *Artogeia* Verity was formerly included in *Pieris* Schrank; however, Kudrna (1974) and Higgins (1975) have correctly separated it.

For the past hundred years, collectors have amassed long series of

butterflies and moths showing the variation of species among different localities, with the expectation that the significance of the diversity would reveal itself, thus exposing the processes of evolution. I think this expectation has generally been disappointed. But at the turn of the century it was believed quite generally that the visible differences between local races expressed their close adaptation to contemporary environmental conditions.

This thesis received considerable support from the experiments of Standfuss (1900) and others on the heat-and-cold treatment of lepidopterous pupae. These appeared to show (*inter alia*) that central European races were convertible into the semblance of Mediterranean races by moderate heat, or into phenocopies of Scandinavian races by moderate cold. It was supposed that environmental factors themselves had the power to produce phenotypes better adapted to cope with them, and that a process rather like that known later as genetic assimilation (Waddington, 1953) had produced the climatic races. The argument was in some degree circular, being based on an initial assumption that the supposed climatic forms were adaptive.

Some local departures from the idealized type were held to be directly environmental, as when marshy conditions were themselves supposed to shift the phenotype in a particular direction, such influence not being inherited. Other deviations were correctly recognized as selective and heritable: "chalk" forms of a butterfly or moth were whiter than heath forms (Poulton, 1890: 157; Ford, 1945: 124; Ford, 1955: 97). There was, therefore, ample excuse for naturalists who attached what might now be called ecological import to all local variations.

Their attitude persists among many lepidopterists. Thus Dennis (1973), in a study of the spotting on the wings of the satyrid butterfly *Coenonympha tullia* Müller in a Welsh colony, concluded that "certain broad spatial features emerge that may prove vital to an understanding of the ecological pressures on *C. tullia*," when his painstaking analysis had established that localized demes differ in spot arrangement. I do not question that local variation occurs, in genotypes as well as in phenotypes; but it is by no means certain that the groups delimited by marking owe their visible differences to their present ecologies. Another example is the strange data concerning spotting on the hindwing of *Maniola jurtina* L. in England, claimed as providing ideal material for investigating adaptation and the action of natural selection (Dowdeswell, 1956). No adaptation was detected, and the basis of natural selection remained quite uncertain, "presumably of a physiological nature."

The significance of wing-pattern is a matter of natural history, requiring in the first place no very specialized techniques for its appraisal.

Indeed, the replacement of the chase by genetic experiment, and even the application of statistical methods, have not in most cases explained geographic variation at specific or subspecific levels though we are able to talk more precisely about it. Nevertheless, I will attempt to reassess the position—the present position—in relation to one group of pierid butterflies. This is a very narrow foundation on which to erect any general principles, but it may be adequate to invalidate the extreme neo-Darwinian dogma.

PART I. MORPH SYSTEMS IN THE *ARTOGEIA NAPI* SPECIES-GROUP

In the species-cluster *Artogeia napi* L., *A. (n.) bryoniae* Ochsenheimer and *A. melete* Ménétriers, we are faced with groups of almost conspecific taxa, with wing ground-colors varying from nearly pure white to deep golden yellow and to a tawny ochre, carrying melanic markings varying from intense and extensive to evanescent. The ground-colors are due to related pterins, and the melanic pattern has a common basis in all the populations.

The wing-pattern variation of the *napi-bryoniae* group in Europe was meticulously described and figured by Müller & Kautz (1939). Their treatment of the Asiatic and American taxa was very incomplete and included few or no illustrations. Indeed, I know of no comprehensive study of the Nearctic members of this group, nor have I myself all the material necessary for such an undertaking. *Artogeia melete* and some associated Asiatic species were the subject of illustrated papers by Sheljuzhko (1960–69). The present work is not concerned with the characterization of taxonomic entities as such, nor will descriptions be in greater detail than is required by subsequent discussion. The accompanying figures (Figs. 1–40) are far from illustrating the total range of variation encountered in the superspecies: nor do they include any forms that can fairly be regarded as “aberrations.”

It will be convenient to consider background colors (sections 1, 2), the markings of the hindwing underside (section 3), and upperside markings (sections 4, 5). Finally the reflection of ultraviolet light, invisible to vertebrates, will be dealt with in section 6.

These groupings of characters do not exhaust those which might be considered to have a fairly simple polymorphic basis. For example, in many *Artogeia* taxa there is normally a small orange-yellow lunule or streak near the base of the hindwings, below. Furthermore, in some Asiatic species, but not others, the forewing discal cell is invaded below by black scales (character “nigrosparsa”). These appearances will not be considered further here.

1. The sulphurea Schöyen polymorphisms¹

European *A. napi* subspecies typically have a white upperside; the underside of the hindwings and of the forewing apices (i.e. those parts exposed when the insect is at rest) are yellow in ground-color. The remainder of the forewing underside is white. In the male the yellow is usually rather paler than in the female.

In the rare variant formerly bred by Head (1939; see also Bowden, 1954) the white pigment is replaced by lemon-yellow, which may be very brilliant if the adult develops at a high temperature. When this yellow is paler, it can be seen that the hindwing underside remains brighter than the upperside: that is, the typical pattern persists. This form occurs equally in both sexes, and is recessive to wild type.

Another sulphurea allele appears to be responsible for Thompson's pale yellow, a form which is fairly distinct in the female, but often almost indistinguishable from wild type in the male. It also is recessive, but is dominant to Head's form. It is uncertain how commonly the gene or gene-combination determining it occurs in England and in other parts of Europe. A genetic study was made by Bowden (1961), but further work on a wider basis is desirable.

Whereas Head's bright yellow does not occur regularly in any natural population, a form indistinguishable from Thompson's, and with the same dominance relationships, is typical of *A. (napi) marginalis* Scudder of Oregon. It may occur also in certain other American populations, but at present it is not known whether it is anywhere in polymorphic balance with the white form (Bowden, 1970).

In various *bryoniae* populations of the eastern Alps (and probably elsewhere) a dominant gene in some of the individuals prevents the development of the lemon-yellow (sepiapterin) color but does not affect the ochreous color which many females show (see section 2). The resulting male phenotype (f. *subtalba* Schima) is white above and below, but nearly all the corresponding females have hindwing undersides which remain ochreous, though their lemon tinge has been lost. The frequency of this gene (another allele of the sulphurea series: Bowden, 1963) is locally as high as 0.25 in the alpine region and the system is there truly polymorphic.

In those European *napi* populations in which the great majority of females are white above, the *subtalba* morph is virtually unknown. Nor does it appear in the arctic ssp. *adalwinda* Fruhstorfer. The extent and

¹Infra-subspecific names (such as sulphurea) are not italicized, but are given the author's name when first used. The names of characters, if new or not well known, are put in quotes when first used, but not afterwards.

mode of its known occurrence in mainland Asia (e.g. Amur) is unfortunately still obscure.

In the eastern Nearctic species *A. virginiensis* Edwards a subtalba gene (also dominant and an allele of sulphurea: Bowden, 1966) is fixed. Here males as well as females possess a little ochreous pigmentation, which prevents a conspicuous white underside in either sex. On the other hand the sympatric *P. (napi) oleracea* Harris has a light lemon-yellow underside in both male and female, and we have not yet encountered a subtalba form in it.

Artogeia melete melete (Japanese) appears to lack sepiapterin in both sexes, but here again males as well as females have considerable ochreous pigmentation (especially on the hindwing underside). This could be regarded as a subtalba form, but it differs genetically from Schima's original subtalba, being apparently recessive when hybridized with typical *napi* (Bowden, 1975).

A. japonica, described by Shirôzu (1952) as a subspecies of *napi*, is specifically distinct from both *A. (n.) napi* and *A. melete* (Bowden, 1978a). In appearance it approaches very closely the artificial hybrid between these two species, but it is of subtalba form and again the subtalba is recessive to *napi* wild-type. In this species the underside of the male is white, *not* ochreous.

A. dulcinea Butler and some other far eastern taxa possess subtalba forms, but in all these cases it is still uncertain whether a balanced polymorphism exists.

2. The female form *flava* Kane

As mentioned above, in some (particularly alpine and arctic) populations the wings of the female (but not of the male) are tawny or ochreous yellow. The responsible pigment (erythropterin, possibly with other related compounds) is present not only on the upperside but also on the hindwing underside, though not normally on the underside forewing disc. Occasionally even this area is more or less ochreous: in ssp. *neobryoniae* Sheljuzhko such specimens are not rare; they occur also in the arctic ssp. *adalwinda*.

In ssp. *britannica* Verity of Ireland and Scotland the sex-limited ochreous variant has wrongly been regarded as an aberration, and named *flava* Kane. In fact it occurs regularly in both populations and its ground-coloration is apparently identical with that typical of *adalwinda* females. As it is unrecognizable in the male and even in the female has variable expression, its genetics have perhaps never been adequately investigated.

The results published by Lorković (1962), however, allow the pos-

sibility that in *bryoniae* it is unifactorial and dominant, if incompletely so, the depth of color developed depending presumably upon modifying genes. The results (1956 and unpublished) from my own hybridizations between *bryoniae*-like subspecies and various white forms are in accordance with this finding.

The occurrence of ochreous pigmentation in both sexes of *A. virginiensis* and *A. melete* has been mentioned above. Since in these species the pigment switch is not completely sex-controlled, it must in some way differ genetically from that in *A. napi* and *bryoniae*.

The apparent association of flava color with ultraviolet reflectance will be discussed in section 6.

3. The underside "green veining"

The species-group is characterized by the borders of black or grey scales on either side of the veins on the hindwing underside. When the ground-color is yellow, the visual effect is greenish, though this effect is lost if the black is too dense or the ground-color is white.

For the purpose of comparisons we shall take as standard the black bordering as it appears in the spring emergence of English *A. napi* (Figs. 2, 7). In the non-diapause generations the density of the bordering is much reduced: an extreme reduction appears in *A. napi meridionalis* Heyne (Figs. 13, 17) of Mediterranean countries. Curiously, warming English *napi* pupae after completion of diapause leads to slightly *increased* melanic scaling on the underside (Bowden, 1978b). In any one population the width of the border does not usually vary very much, though very broad borders (obscuring most of the ground-color) frequently occur in *A. napi adalwinda* (Fig. 26) and *A. n. hulda* Edwards.

A rather broad, vaguely defined vein-bordering characterizes *A. virginiensis* (Fig. 29) and helps to separate it from the sympatric but ecologically distinct *A. (n.) oleracea*. In the Near East flies *A. (n.) dubiosa* Röber (= *pseudorapae* Verity); the better known non-diapause generations have vein-marking so nearly obliterated as to justify both its names, but in the diapause generation form *suffusa* Verity, which appears to belong to *dubiosa*, carries very broad vein-stripes.

A. (n.) oleracea (Figs. 32, 34), like *A. melete* (Fig. 21), has narrow and sharply defined vein-marking, which in the spring emergence can be extremely densely black or chocolate-black. In the non-diapause generation (Figs. 37, 39) the borders remain narrow, but are only slightly pigmented and often hardly visible. This "acuta" type of vein-bordering, found also in the Californian *A. (n.) venosa* Scudder, is dominant over both European wild type and the suffused bordering of *A. virginiensis*

(Bowden, 1972). It retains its general character in hybrids repeatedly back-crossed to European *napi*, but the "summer" veining is then more visible than in the pure *oleracea* gene-complex. The *acuta* veining of *A. melete* (Figs. 21, 23) also is dominant in hybrids (Bowden, 1975).

All these modifications of the underside veining are retained when the subspecies concerned are bred in England. It should be said that though the "seasonal" dimorphism is normally a simple consequence of the diapause/non-diapause alternative, some intermediate phenotypes (on both surfaces of the wings) can occur in special circumstances (Bowden, 1978b).

4. The upperside markings

Again it is convenient to regard the markings of spring *napi* of southern England (Figs. 1, 6) as normal, as well as most appropriate for the comparison of univoltine populations such as *A. n. adalwinda* and *A. (n.) bryoniae*.

In the male (Fig. 1) the forewing discal spot varies in size within the same subspecies and may be absent, though in this case one or two spots on the underside of the forewing (Fig. 2) normally remain. The female marking (Fig. 6) includes on the forewing two discal spots, with often a supra-discal spot more or less covered by the extension of the apical. The pre-apical costal mark prominent in *A. krueperi* Staudinger is sometimes faintly represented, and may be distinguishable from the supra-discal spot proper (when both are present) by a different degree of melanization. These additional spots are sometimes apparent in males also (especially in non-diapause emergences), but a dark streak along the hind margin is normally characteristic of the female sex. The dark basal suffusion is more extensive in the female, whose forewing veins are lined-in, especially towards the outer margin, where this black scaling commonly expands to form dark triangles.

On the fore-margin of the hindwing of both sexes there is usually a black spot, more or less in line with the forewing discal spots but homologous rather with the apical. Marking along the hindwing veins is variable, but generally light.

In *bryoniae*-like forms (Figs. 4, 9, 27) the female radial vein-marking is intensified and broadened, and an additional streak ("Saumstrich" or "bryo-streak") appears outside the middle of the lower (i.e. posterior) discal spot; basal and marginal dark suffusions may also become extensive. The combinations of these elements in various proportions are infinitely varied, so that no two females are entirely alike. Stipan et al. (1960) attempted the thankless task of completing Kautz's descriptive

naming (Müller & Kautz, 1939) of the main possible forms. Development varies between and sometimes within populations from a mere bryostreak to the extreme f. concolor Röber, approached by Fig. 9. The not uncommon f. "meta" is illustrated in Fig. 5. Clearly the *bryoniae* phenotypes cannot be due to a single dominant gene, as has sometimes been supposed. Apart from modifiers, there may be several linked major genes involved. Probably only the "radiata" element has been adequately studied genetically, and this is indeed a simple dominant (Lorković, 1962).

In non-diapause individuals (Figs. 3, 8) the spots become more prominent, the radial markings less so. Extreme forms, in this direction, are found in the summer broods of *A. n. meridionalis*. Females representative of this subspecies (Fig. 16) lack even the marginal black streak continuing the upper edge of the lower discal spot; this streak is always absent in *A. rapae* L. (Fig. 20).

Even in summer males, the discal spot can be completely absent (as it is in *Pieris brassicae* L.), but this is uncommon in Europe. The aspect of both sexes is changeable by a varied development of the supra-discal spot and its confusion with the apical (Fig. 12).

The upperside markings of *A. melete* (Figs. 22, 24) differ from those of *A. napi* by their greater intensity and breadth, which frequently leads to their confluence. In the male *melete* the second discal spot appears regularly.

5. Restricted upperside markings

When over-wintering pupae which have completed diapause are held at varying temperatures between 0°C and the temperature of normal development (ca. 6–8°C) some individuals are diverted to produce a "superspring" form (Figs. 14, 19). Though the forewing apical spot and the corresponding spot on the hindwing may persist, the discal spot markings disappear completely or almost so, even from the female and even on the underside, and the radial veins are more or less blackened throughout their length. In extreme examples the sexes become alike (Bowden, 1978b). This form, which can be obtained in several (perhaps all) European subspecies, including *adalwinda* and *bryoniae* (Fig. 18), may be called "restricta"—the name referring to a character and not to any taxonomic entity. Genetically, the treated insects showing it are quite normal (usually wild type) for their subspecies.

Some Nearctic *napi* subspecies present a similar or more extreme appearance even in their natural temperature regime. *P. (n.) oleracea* may be quoted: in both diapause and non-diapause generations (Figs. 31–34,

36–39) the *napi* spot-markings are faint or completely absent, the apical marking is weak and there are no spots even on the underside of the forewings; on the upperside even radial marking is slight or absent. In *oleracea-napi* hybrids this genetically determined *restricta* behaves as a simple recessive, linked with the dominant *acuta* (Bowden, 1972).

Ssp. marginalis (Figs. 35, 40) is slightly less *restricta* in phenotype than *oleracea*; females usually show the black streak on the forewing hind-margin, the adjacent discal spot (rather weakly) and sometimes a very weak anterior discal spot. Crosses with *oleracea* suggest, however, that the same *restricta* gene is present in both subspecies.

Ssp. venosa Scudder of California lacks the *restricta* character, though *acuta* is present; in this it resembles some taxa of eastern Asia.

6. Ultraviolet patterns

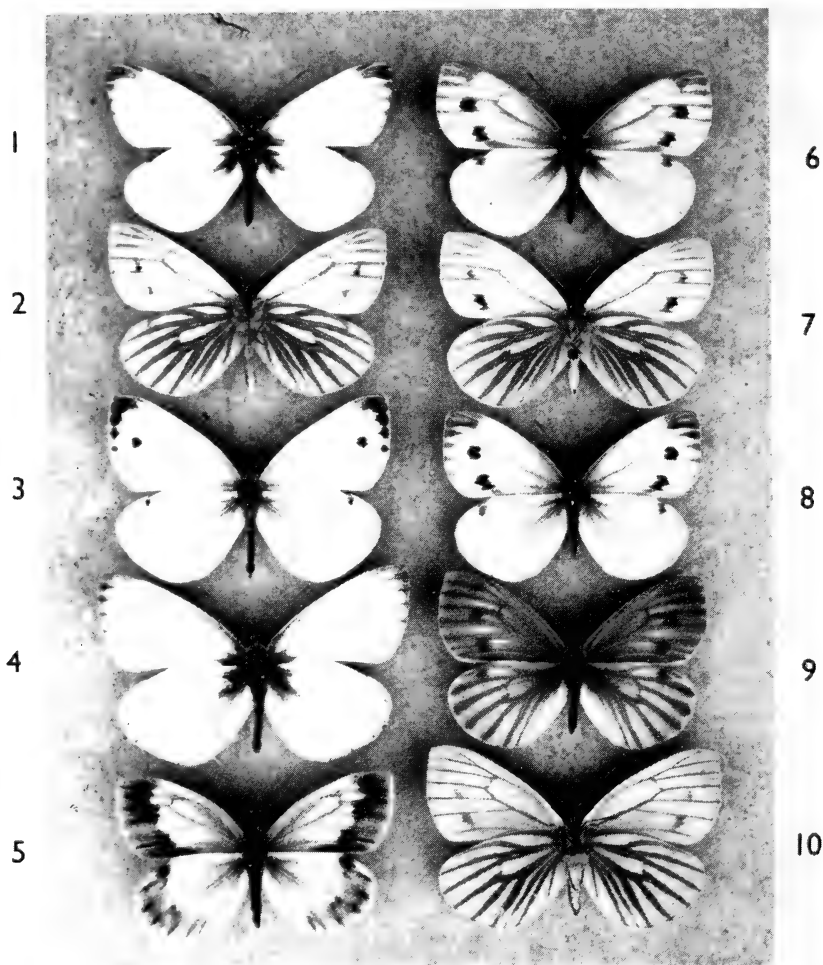
In recent years many workers have studied the reflection of ultraviolet light by butterflies. Among the Pieridae, the yellow butterflies such as *Gonepteryx* (Nekrutenko, 1964), *Colias* (Ferris, 1973) and *Eurema* (Ghiradella *et al.*, 1972) show ultraviolet-reflecting patches in the male only, and these are structural, a complex lamellar system on the ridges of the scales producing optical interference.

In *Artogeia*, on the contrary, the males usually remain dark (as do the females also in *A. napi napi*), but in many subspecies the female upperside reflects more or less strongly. This is so particularly in those European taxa in which the female ground-color is ochreous, but *A. (n.) macdunnoughii* Remington of Colorado and *A. melete* have nearly white females which are rather brightly reflective. Experiment shows that absorption by varying concentrations of leucopterin in the wing-scales and (in the females) structural reflection are responsible for the differences (Bowden, 1977).

PART II. ADAPTATION AND SELECTIVE NEUTRALITY

From the time of Darwin (1859) on, the basic idea connecting variation with evolution has been that of adaptation—often a vaguely formulated idea, leading to tautological arguments whose circular character easily escaped detection.

In some balanced systems, such as the melanisms (Kettlewell, 1973) and the mimetic complexes (Sheppard, 1961), there are indeed good reasons for supposing that primary selective advantages are involved and often the basis of selection can be proposed with confidence. The selection is intraspecific, acting on the individual, so that in particular circumstances one allele is favored up to an equilibrium level. Population



EXPLANATION OF FIGURES

- | | | | | | | | | | | | |
|--------|-------------------|----|------|---|------------|----|---|----|------|---|--------------|
| Fig. 1 | N | L. | ups. | ♂ | '65 X2 | 6 | N | L. | ups. | ♀ | '46 Cornwall |
| 2 | N | L. | uns. | ♂ | '69w'22 | 7 | N | L. | uns. | ♀ | '69w'25 |
| 3 | N | S. | ups. | ♂ | '50 Herts. | 8 | N | S. | ups. | ♀ | '44 Essex |
| 4 | B | L. | ups. | ♂ | '73b'10 | 9 | B | L. | ups. | ♀ | '63E59 |
| 5 | (BN) ² | S. | ups. | ♀ | '52t10 | 10 | B | U. | uns. | ♀ | '73b25 |

Abbreviations: A = ssp. *adalwinda* (Lappland), B = ssp. *bryoniae* (Swiss), (BN)² = F₂ hybrid ♀ B × ♂ N, D = ssp. *meridionalis* (Corsica), J = sp. & ssp. *melete* (Japan), K = ssp. *neobryoniae* (Kärnten), KA = F₁ hybrid ♀ K × ♂ A, M = ssp. *marginalis* (Oregon), N = ssp. *septentrionalis* (England), O = ssp. *oleracea* (New Hampshire, U.S.A.), Ra = sp. & ssp. *rapae* (England), V = sp. & ssp. *virginiensis* (Connecticut, U.S.A.). L. = from diapause pupa, S. = from non-diapause pupa, ups. = upperside, uns. = underside. Figures and italic letters following sex-signs are individual identifications.

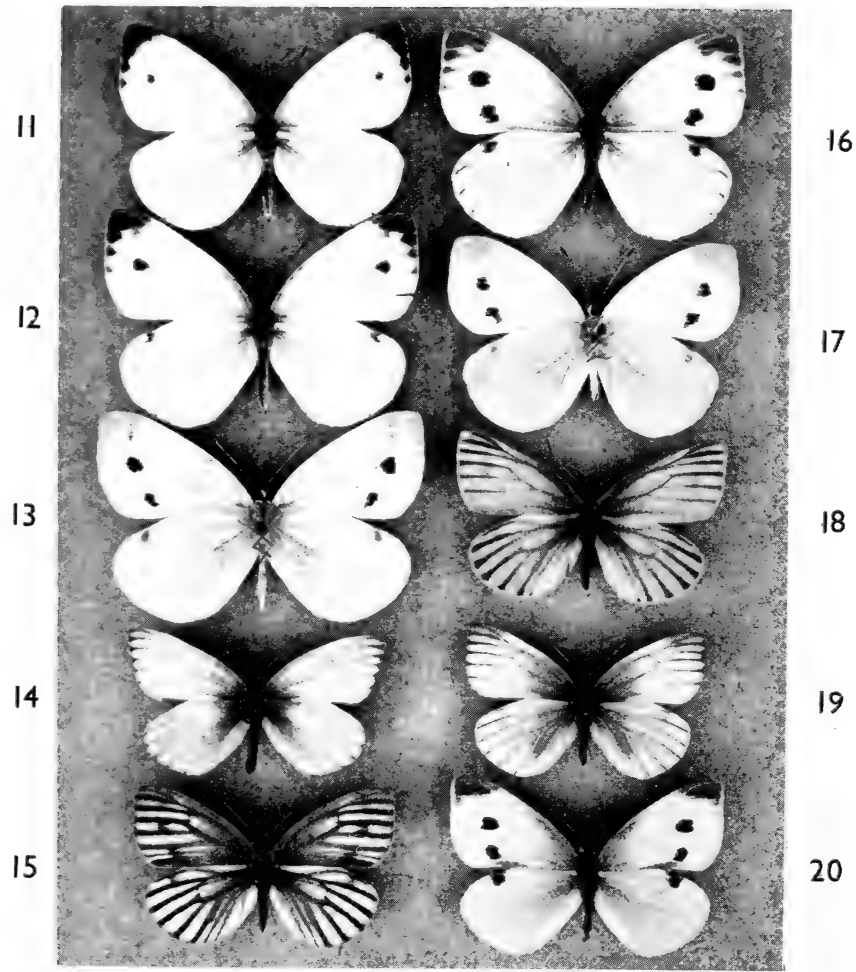


FIG. 11	D	S. ups.	♂	'64d ^{vi} 45	16	D	S. ups.	♀	'64d ^{vi} 25
12	D	S. ups.	♂	'64d ⁱⁱ 5	17	D	S. uns.	♀	'64d ^{vi} 74
13	D	S. uns.	♂	'64d ⁱⁱ 11	18	B	L. ups.	♀	'72A24
14	N	L. ups.	♂	'70t ⁱ 8	19	N	L. ups.	♀	'70t ⁱ 6
15	KA	L. ups.	♀	'53a24	20	Ra	S. ups.	♀	'64 Herts.

Editor's Note: Figures reduced to 0.88 of original size.

density is not usually determined by such selection: it can seldom happen that the population-level of an insect is fixed by the bird predation which is selecting the cryptic or mimetic adult.

There has been a widespread opinion, following Fisher's (1930) argument, that genes having a neutral effect, that is on balance neither advantageous nor disadvantageous, are necessarily extremely rare. All

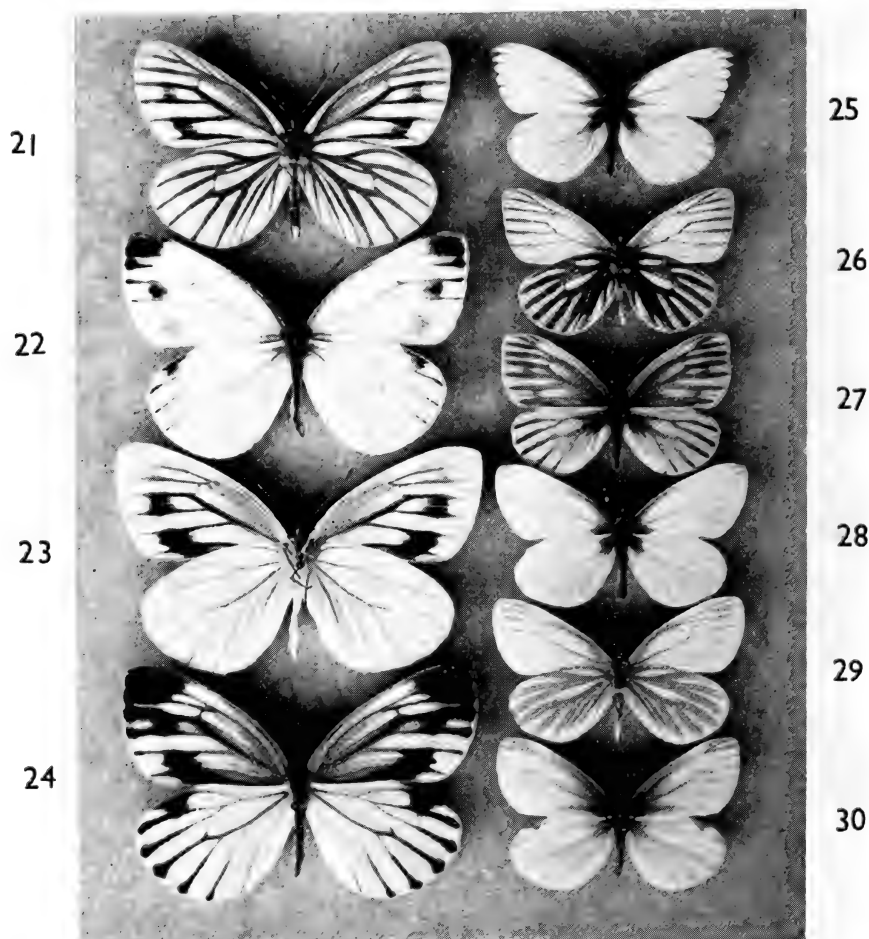


FIG. 21 J L. uns. ♂ '71J'11
 22 J S. ups. ♂ '72J¹¹'16
 23 J S. uns. ♂ '72J¹¹'10
 24 J S. ups. ♀ '72j¹¹'7

25 A L. ups. ♂ '52K2
 26 A L. uns. ♂ '54d33
 27 A L. ups. ♀ '54d95
 28 V L. ups. ♂ '72v6
 29 V L. uns. ♂ '72v5
 30 V L. ups. ♀ '66y¹¹'6

Abbreviations: A = ssp. *adalwinda* (Lapland), B = ssp. *bryoniae* (Swiss), (BN)² = F₂ hybrid ♀ B × ♂ N, D = ssp. *meridionalis* (Corsica), J = sp. & ssp. *melete* (Japan), K = ssp. *neobryoniae* (Kärnten), KA = F₁ hybrid ♀ K × ♂ A, M = ssp. *marginalis* (Oregon), N = ssp. *septentrionalis* (England), O = ssp. *oleracea* (New Hampshire, U.S.A.), Ra = sp. & ssp. *rapae* (England), V = sp. & ssp. *virginiensis* (Connecticut, U.S.A.). L. = from diapause pupa, S. = from non-diapause pupa, ups. = upperside, uns. = underside. Figures and italic letters following sex-signs are individual identifications.

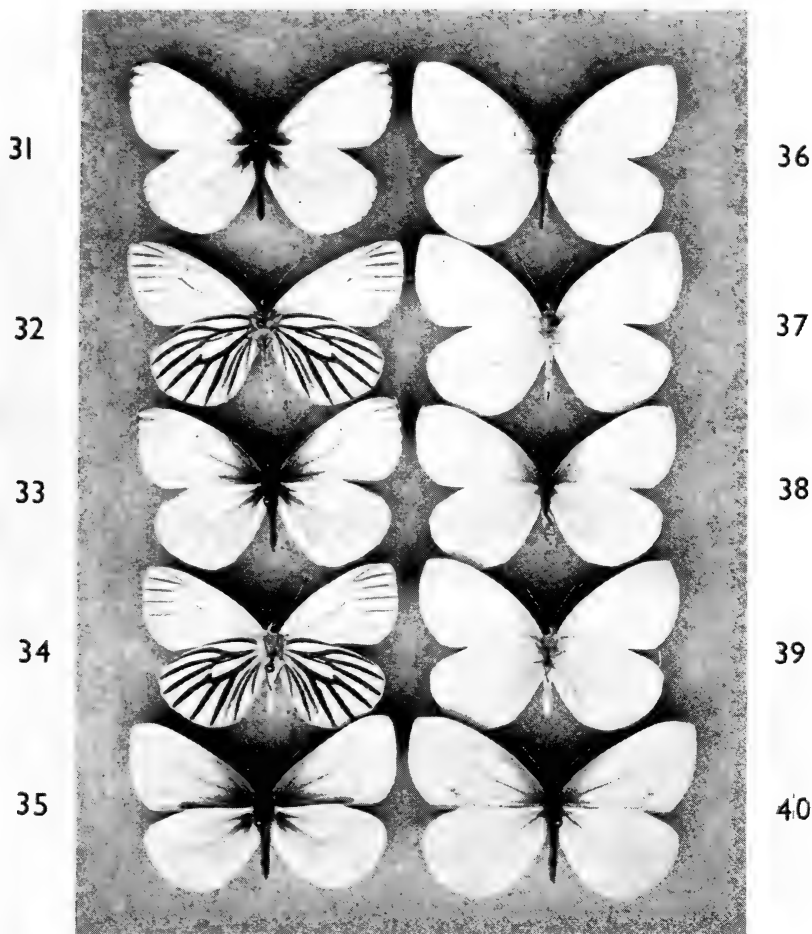


FIG. 31 O L. ups. ♂ '65o'16 36 O S. ups. ♂ '65O22
 32 O L. uns. ♂ '65o'13 37 O S. uns. ♂ '65O27
 33 O L. ups. ♀ '65o'12 38 O S. ups. ♀ '65O30
 34 O L. uns. ♀ '65o'39 39 O S. uns. ♀ '65O32
 35 M L. ups. ♀ '66Mⁱⁱⁱ10 40 M S. ups. ♀ '68oⁱⁱⁱ9

Editor's Note: Figures reduced to 0.88 of original size.

present characters of subspecies must then be expected to have been positively selected, that is, to be "adaptive." When visible characters appear to have no conceivable selective value, appeals to the pleiotropy of genes are commonly made to escape the contradiction: a correlated physiological modification, perhaps affecting behavior or environmental response, is assumed. When the phenotype in question varies locally in frequency it is necessary to think of a covert character, controlled by the

gene concerned, which would have different optimization in the various localities. Such characters are not entirely nonexistent, but how are they to be identified? And as Robson & Richards (1936: 274) remarked, "It is no use to smuggle these facts of specific differentiation into the proof of natural selection by an appeal to ignorance, or by an assumption of correlation." In fact an hypothesis supported by a supposition of pleiotropy has no standing until at least the close genetic linkage of a known associated effect has been independently established—calculation of a statistical correlation is seldom convincing by itself.

Moreover, as modifying genes were supposed ultimately to render unfavorable characters recessive (Fisher, 1929), so they should also reduce the penetrance or expressivity of such characters in pleiotropic systems. The appeal to pleiotropy itself admits that the positive selection of a gene need not imply positive selection for all the characters controlled by the gene; visible characters may then well be neutral. And if some of the characters controlled by a pleiotropic gene can be non-adaptive, these seems no reason why other phenotypic characters should not be so. Thus the argument from pleiotropy may be set aside as for our purpose irrelevant. Our concern here is with visible characters: have they been positively selected by external forces, or are they maintained as externally neutral factors in some well-balanced genetic complex? One should allow that even a character originally fixed by selection may thereafter become effectively neutral in a variable environment. For plants, Stebbins (1974) has pointed out that many complex adaptive structures have been retained long after the strong selective pressures that were required to establish them have ceased to exist (e.g. in self-fertilizing Leguminosae and apomictic Compositae). We shall suggest that whether or not genes can rarely be neutral, characters controlled by them quite commonly are. This can hardly be denied (Ford, 1945a: 78).

Curiously, no one seems to maintain that characters which have become specific ones are fixed by environmental agencies. *Clossiana selene* Schiffermüller and *C. euphrosyne* L. are now sympatric and the differences in their patterns owe nothing to present local conditions. How are the wing-markings of *Nymphalis antiopa* L. determined? Normalizing selection is working on ancestral genotypes, probably with no visible response to ecological conditions. If we consider two *Artogeia* species which have become sympatric, say *A. napi* and *A. rapae*, it is clear that at some unknown time these had a common stock, which has since been subject to repeated splitting. It would be difficult to believe that present ecology determines their pattern-differences; why then should we believe that it does so for allopatric ssp. *napi* and ssp. *oleracea*?

In the last few years Fisher's "dogma," which led to various para-

doxical results in the hands of other mathematicians, has indeed appeared less cogent. "Mutations" rather suddenly came to include not only conspicuous alterations of the phenotype but also changes in proteins, detectable by electrophoresis, and even replacement of one genetic codon by a synonymous one. Changes in proteins in the course of evolution were investigated by their analysis in nearly and distantly related taxa (Goodman et al., 1971). King & Jukes (1969) concluded, rightly or wrongly, that at the molecular level most evolutionary change might be due to selectively neutral mutations and genetic drift. Kimura & Ohta (1971) also maintained that the protein polymorphisms known from electrophoretic data were transient phases in the random-walk fixation of neutral mutations. Theoretical difficulties were exploited, or explained away, by the mathematical population-geneticists (e.g. Karlin & Nevo, 1976) though, as M. Nei said in discussion, "We cannot make a general inference about nature from a study of a specific mathematical model." But evidently a belief that neutral mutations may have a part to play, at the allozyme or even at the morphological level, no longer involves the scientific ostracism of its holder.

ADAPTATION IN *ARTOGEIA*

In what sense are the characters which visibly differentiate related populations of *Artogeia* adaptive? What common agencies could be expected to exert selective pressure, on the basis of visible characters?

Firstly, the physical environment itself might be directly operative, or might interact with physiological processes.

Secondly, predation by birds, lizards and various arthropods might be influenced by the procryptic or apostatic patterns of individuals.

Thirdly, such predation might be reduced, in unpalatable groups, by warning coloration.

Fourthly, intraspecific pairing might be facilitated, and interspecific pairing discouraged, by the butterflies' recognition only of the appropriate patterns.

These, the more obvious possibilities, will now be considered.

1. Physical environment

It must first be remarked that the genus *Artogeia*, as well as many Satyridae, has been particularly influenced by the climatic changes of the last few hundred thousand years, and it may well be that some distribution-changes are too recent for close approach to genetic equilibrium. As will be seen, this may affect the validity of some arguments.

Subspecies in this group differ in mean size, but so do the two or three generations annually within a subspecies. Particularly common is a slight dwarfing in later summer emergences, attributable to the effect of drought on food-plants. In general, however, *napi* populations from the Mediterranean region tend to produce large adults. Levins (1968) has remarked that contra-gradient variation is common among invertebrates—those in hotter, drier regions may be “genetically” larger to attain the same actual size in their own environment. One effect of the conflicting factors has been to produce some extreme individuals in these climates (cf. Holl, 1914; Warren, 1970). Inter-subspecific dimensional comparisons are therefore best made between insects reared together in captivity; otherwise it is easy to draw incorrect conclusions.

The physical environment certainly exercises control over other physiological adjustments, and also modifies the expression of subspecific wing-characters in each individual; but convincing evidence for its selective influence on these last has been almost entirely lacking.

The absorption of solar radiation and its conversion into heat assists poikilothermic animals to become active. Watt (1968) has studied the thermoregulation of six species and subspecies of *Colias* and shown experimentally that the greater melanization of the underside in the higher altitude populations helps them to approach their optimum temperature by appropriate orientation behavior.

Two circumstances may be thought to favor the suggestion of a similar role for the melanic marking of *A. napi*, as has indeed been postulated by Shapiro (1977) in the case of *A. n. venosa*. Firstly, the underside veining of the summer broods is always lighter than that of the spring emergence of the same subspecies. Secondly, the summer broods of the Mediterranean populations are less extensively melanized below than those of central and northern Europe. However, the interrelation between the directly environmental (diapause/non-diapause) and the inherited factors in these differences makes it difficult to estimate the likelihood of their adaptive origin.

Nor is climatic basis of the melanic cline very certainly established. Descimon & Renon (1975), working with the satyrid butterfly *Melanargia galathea* L. in France, found a melanization gradient exactly contrary to that presented by *A. napi* populations; nevertheless they did not fail to find an eco-climatic rationale.

Again, the explanation usually given for the ochreous color and melanization of ssp. *bryoniae* and *adalwinda* females is that the pigmentation serves to increase absorption of radiation and so enables these females to reach a relatively high body-temperature at high altitudes and latitudes. However, the males too need to attain a certain temperature for

successful fertilization; also *Pontia callidice* Hübner at even higher altitudes lacks ochre pigment and is not particularly heavily marked.

In the *Colias* polymorphism involving the form *alba* (or *helice* Hübner) the frequency of the paler pterin pigmentation actually increases towards the far north (Hovanitz, 1944), although Watt (1974) showed that in *C. eurytheme* Boisduval orange females heat up more rapidly in sunlight than *alba* females, as would be expected from their greater absorption of blue light. But Lorković & Herman (1963) confirmed the unequal viabilities of the *C. croceus* Fourcroy genotypes at different temperatures in experimental conditions which presumably eliminated any color effect. Descimon's (1976) conclusion would make the color-difference an incidental consequence of the diversion of nitrogenous compounds from pigment formation to egg-nutrition in the *helice* form.

Petersen (1952, 1955) has shown a correlation of ochreous pigmentation with relatively heavy melanic marking in *Artogeia* populations of mixed phenotype (ssp. *neobryoniae*). Since both characters are more or less completely dominant, this correlation might be, at least in part, a consequence of hybridization of a genotype producing both with a genotype producing neither. There is no evidence of linkage (Lorković, 1962; Bowden, 1956 and unpublished): the expected recombinations take place in the experimental F_2 and the corresponding phenotypes are to be found also in the wild. In the Fennoscandian territories occupied by ssp. *adalwinda*, *bicolorata* Petersen and *napi*, Petersen (1949) found that the clines for female ochreous ground-color and for heavy melanic marking did not altogether coincide.

Lorković (1962) concluded that "we can say very little about possible pleiotropy of the color genes" and that if there were no correlation with physiological and ecological characteristics there must be a directly genetic selective advantage. Local variation of the frequency of morphs was earlier considered to be a reliable indication of the action of selection. Perhaps this begged the question a little.

How the *subtalba* balance is maintained, ecologically or genetically (by heterozygous advantage), is not yet known. Bowden (1967) disproved the suggestion of lethality of the homozygote, but could not exclude, in the varying genotypes of the eastern Alps, the possible association of *subtalba* with linked genes which reduced the number of homozygous females in some broods.

Ford (1964: 291) says, "The *bryoniae* complex of genes and characters evidently fits the butterfly for life at high altitudes and latitudes. . . ." but "It seems unlikely that the same genes are responsible for *bryoniae* throughout the whole of its discontinuous distribution." Since the different elements of the *bryoniae* phenotype (see above, under "Upper-

side markings") are unequally developed in different localities less than 500 km apart, this is certainly true to some extent, but his further discussion would suggest that *bryoniae* is not a monophyletic group, similar characters having instead been selected, by similar environmental conditions, in local stocks. This is difficult to believe: Petersen (1958) was so convinced of the common origin of the female patterns in ssp. *bryoniae* and ssp. *adalwinda* that he was prepared to allot the latter subspecies to the "species" *bryoniae*, although it belonged reproductively to *napi*.

Robinson (1971) offered the following on f. *subtalba*: "In either *napi* or *bryoniae* the *subtalba* form occurs as part of a polymorphism, but in *Pieris virginiensis* the form is actually the wild type. In the Nearctic habitat of *virginiensis* the conditions so favour *subtalba* that the wild type found in either *napi* or *bryoniae* is completely lacking." Such an ecological "explanation" explains nothing; besides, it is partly contradicted by the *napi*-wild-type coloration of the sympatric *A. (n.) oleracea*.

A further objection to facile ecological derivations is that in this group of butterflies each population has some freedom to select its own habitat in a locally varying environment. The phenotype, in fact, comes to choose the kind of selection to which it will be exposed (Waddington, 1967). It is even reasonable to suppose that if the American and European *napi* populations were wholly interchanged they would survive by this means, each with its own markings, though the *oleracea* colonies in Europe would not necessarily persist in the precise localities now occupied by *A. napi*.

2. Cryptic patterns

It seems obvious enough that the veined pattern of the underside contributes much to crypsis at rest, as do the mottled patterns of some other pierids (*Pontia*, *Euchloe*). The usually yellow ground-color, whether lemon or ochre in tint, adds to the success of this effect. It is notable that in most of those morphs or subspecies which lack the lemon-yellow sepiapterin, the females or even both sexes have available another pigment (essentially erythropterin) which produces a pale orange (ochreous) effect (Bowden, 1966). The basic pattern of the underside can thus well be called adaptive.

The **differences** among the subspecies probably cannot: all variants evidently work sufficiently well. If one compares *oleracea* with *napi*, it is difficult to suppose that the former benefits from its more conspicuous veining in spring, since this veining practically disappears in non-diapause emergences. Can its American niche demand veining more definite than the European in spring, less definite in summer? Have these butterflies, in all localities, less need for crypsis in summer than in spring? It is

difficult to answer these questions in the affirmative. The differences are surely not cryptically adaptive.

The subalba polymorphism (where it exists as such) could be maintained by selection of apostatic forms (Clarke, 1969), in this case by preferential predation of the locally commoner form of male. In the female, with its greater reliance upon crypsis, the morphs are not very unlike (relative to the variation within each morph) and even the most discriminating predators would hardly distinguish between them. But this possible mechanism may in any case be precluded by aposematism.

3. Warning coloration

Poulton (1890: 185) remarked, "The colours which produce . . . the greatest effect, upon the eye of an insect-eating vertebrate, are black and white. . . ."

It has been stated that *Pieris* and *Artogeia* (especially perhaps *P. brassicae*) are distasteful to birds, and that the white color is aposematic. I have indeed observed that sparrows (*Passer domesticus* L.) are not always effectively deterred from taking *P. brassicae*, and a captive European gecko captured and ate the same insect. Collenette (1935) quotes numerous anecdotal reports of attack by birds on *P. brassicae* and *A. rapae* (and on an occasional *A. napi*); in very few was the insect rejected after being secured. However, there were some observations of definite avoidance. Probably attacks are far fewer than a palatable insect would suffer.

Indeed, Rothschild *et al.* have recently established (Marsh & Rothschild, 1974) that all three British whites feeding on crucifers contain toxic substances which would render them relatively noxious to birds, though only *P. brassicae* is sufficiently so to have evolved aposematic rather than cryptic coloring in the larval stage. The mimicry is Mullerian rather than Batesian, since not only is the supposed model, *brassicae*, usually less numerous than *rapae* and *napi*, but these mimics are themselves toxic.

Certain further facts do support the synaposematic hypothesis:

- (i) The close pattern-resemblance of *Artogeia rapae* to *Pieris brassicae*, an insect otherwise so different as to merit its full generic separation (cf. Warren, 1961, Kudrna, 1974).
- (ii) The full development of the same pattern in *A. napi* only in the Palearctic region, where *A. rapae* flies naturally.
- (iii) The formation of a similar Mullerian (?) group in eastern Asia, by *A. melete*, *A. japonica* and *A. napi*, again with *A. rapae*. Here the

superficial resemblance of *japonica* to *melete* is very close indeed (*A. melete* is toxic—Rothschild, Marsh & Bowden, unpublished).

However, one would say that, to predators, differences in the black upperside patterns exhibited by *A. napi* subspecies in most different localities would probably be irrelevant, neither adding to nor detracting from any deterrent effect. And *napi* does vary independently of its "models" within the European and east Asiatic regions. *A. ergane* Geyer, which belongs to the wider *napi* grouping, is a much closer mimic of *A. rapae*.

If, as seems likely, the white butterflies evolved originally from yellow or orange ones not unlike *Colias*, the aposematic effect of white may have contributed to its success in replacing orange. But orange-and-black, too, is a warning coloration, and Collenette (*loc. cit.*) quotes a case of house sparrows taking white butterflies but neglecting *Colias*.

The pale lemon yellows found in rare variants in Europe would be aposematically inferior to both orange and white, but if so the fixation of "pale yellow" in the ssp. *marginalis* of Oregon requires a special explanation which is lacking at present.

White is conspicuous in nearly all *Pieris* and *Artogeia*, except that in the *bryoniae*-like subspecies the females are dark and show little white. Since the females' individual protection is the more important to the species, there is an implication here that the males' gain from their whiteness is by no means indispensable.

4. Pair-formation

The experiments of Eltringham (1933), well summarized by Ford (1945b), showed that male butterflies recognize their females at a distance by their color. One can observe that male whites will approach any white butterflies, including other males, though at close quarters scent cues and behavior patterns become more important.

On the other hand Petersen and collaborators found that searching male *bryoniae* are attracted (from a distance) to white *napi* females, even in marked preference to their own dark females (Petersen, 1963).

Petersen's experiment needs repeating and extending, but his reported result could be expected from the apparently dull female coloration, if *bryoniae* react equally to ochreous and white stimuli. But there is a complicating factor: these tawny females reflect ultraviolet light, whereas most white and lemon-yellow males and females do not. As has long been known (Lubbock, 1899) insects not only distinguish colors but also see the near ultraviolet so that these "dark" females might appear brightly ultraviolet. Such reflection is not in fact confined to

ochreous individuals but is just as strong in certain "white" females, for example those of *A. (n.) macdunnoughii*.

The absorption of ultraviolet light by the males' wings renders them "colored" to the females and may help to release pairing behavior, though in conditions of proximity scent is almost certainly predominant.

Obara (1970) claims to show that ultraviolet reflection is the only signal exciting sexual behavior in the *A. rapae* male, and that markings, size and shape of the wings (and even scent) are all irrelevant. This conclusion cannot, of course, be extended to *A. napi*, many of whose females do not reflect ultraviolet.

Adaptation for sexual selectivity between species is given by the existence of any specific difference readily perceptible by the insects concerned; neither form is "superior" to the other, advantage for both being obtained merely by magnifying the difference.

What, then, should be our assessment of the influence of local selective pressures on the visible characters which distinguish related *Artogeia* populations? Wide variability of essentially the same designs would itself suggest either that the variants are approximately neutral in effect, or else that a number of separate optima exist, each related to the local environment. The latter alternative does not accord with observed similarity of phenotype over geographic areas comprising a range of biotopes.

For example, the extensive biotopes of *napi* and *oleracea* in Europe and America vary greatly, as from moorland to deciduous forest, and the heterogeneity is relatively small-scale, with Nearctic and Palaearctic habitats overlapping in character. Clearly the sharply veined phenotype is not being selected by positive environmental pressures peculiar to the New World.

Many subspecies of *A. napi* can be regarded as exerges in the sense of Verity (1925, 1953). In his quoted case of *Mellicta athalia athalia* Rottemberg and *M. a. celadussa* Fruhstorfer, the chief observable distinction is in the male genitalia, but fully fertile interbreeding nevertheless occurs along the subspecific frontier, introgression producing a hybrid zone varying between 50 and 160 km in traceable width (Higgins & Riley, 1970; Higgins, 1975; Guillaumin & Descimon, 1976). Should one suppose that one form of genitalia is adaptive in the conditions of northern and central Europe, the other in Spain and Italy?

Similarly, within the *A. napi* group androconial scale shapes vary; we can see no advantage in this, though as Lorković (1970) has pointed out, variation (if it occurred) in the male scent disseminated might contribute to sexual discrimination; at the specific level the lemon-verbena scent of *A. napi* is quite distinct from the faint sweetbriar of *A. rapae*

(Ford, 1945b). The seasonal androconial differences described by Warren (1961–1967) also must surely be nonadaptive.

We have shown above (see also Bowden, 1978b) that both upper- and underside markings in the *A. napi* group are subject to direct environmental modification; differences between post-diapause and non-diapause adults often exceed those between distinct species. Nor is there sufficient reason to suppose that these phenotypic departures are primarily adapted to special seasonal requirements, though advantage may be taken of them when they favor physiological adjustments. The restricta marking of *oleracea* is nearly phenocopied by European subspecies subjected to an unnatural temperature regime. It is not impossible that the facies characteristic of the various populations are determined by rate-genes which produce differential realization of the elements of the basic pattern, and the seasonal differences are brought about quasi-automatically. Current utility of a character need not imply adaptive origin; the well documented cases of pre-adaptation (cf. Huxley, 1942) are sufficient evidence of this.

There is no need to doubt that these *Artogeia* are well attuned to their rather wide niches, and that this adaptation was achieved through natural selection. Local adaptation, however, seems to be physiological—in respect of such matters as voltinism, temperature-tolerance, etc. This will prevail, whether or not every element of pattern is optimal for the necessary processes.

In the subspecies of *A. napi*, it appears that ecological conditions may now exert little beyond normalizing selection on the genes controlling some visible characters. Elements of the wing-pattern, if they are thus unresponsive to the particular milieu, can be given the greater weight in taxonomy at the species-level and below. The general principle is exemplified even by genitalia and androconia (cf. Robson & Richards, 1936: 299; Ford, 1945a: 79).

Limits of Selection Theory

As Lewontin (1974) remarks, we cannot know the overall importance of balancing selection by demonstrating that it exists—of course it exists. The problem is, what proportion of observed genic variation is maintained by selection? The school of ecological genetics would attempt to solve the problem by establishing and quantifying the selective forces involved in as many cases as possible. But it is doubtful whether anyone has succeeded in measuring the net fitnesses of genotypes for any locus in any species in any natural environment (Lewontin, 1974: 236). Indeed, even attempts to assess reliably the mean relative advantages of

alleles in experimental conditions are defeated by the difficulty of securing a representative set of individuals for the trial (e.g. Bowden, 1967). And necessarily, where selection is frequency-dependent, the establishment of equilibrium proportions implies that the genotypes present are equally fit at that equilibrium. It is to equilibria that published mathematical treatments generally refer—and they are almost powerless to involve real time. Fitness may depend not only on the character of the remainder of the genome, but also on the gene's own frequency in the population (Dobzhansky, 1970). Hartl & Cook (1976) claimed to show that purely random selection could maintain genetic polymorphisms even when the expected fitness of each genotype was the same.

PART III. DISSECTED POLYMORPHISM IN SUBSPECIATION

Dissection of Polymorphisms

Many distinctive characters, as we have indicated, are controlled by single genes, and if the differing patterns coexisted in one population—as they sometimes do—would constitute a classical genetic polymorphism (Ford, 1940, 1961).

Lewontin (1974) has said, on the basis of observations on *Drosophila*, that “the overwhelming preponderance of genetic differences between closely related species is latent in the polymorphisms existing within species.” This must be even truer of those between subspecies, but we frequently find that within *Artogeia* populations there is in fact little heterozygosity in respect of the distinctive characters that we recognize—hence indeed their taxonomic value.

I shall not attempt to discuss here the general question of the maintenance of heterozygosity in *Artogeia* populations. In very few insect species are sufficient data available—certainly not yet in *A. napi*. Studies of enzyme polymorphisms, how they are balanced and how dissected within and between its populations, may soon provide such data and at the same time suggest phylogenetic relationships. Gene-frequencies close to fixation are very insensitive to selection and have hardly any implications about the recent past; on the other hand a gene-frequency close to 0.5 offers chiefly information about the recent past and essentially none about the remote past (Lewontin in Moorhead & Kaplan, 1967).

Consider a former polymorphic species extending its range and in the course of ages being divided by geographic catastrophe or otherwise into isolated subspecies. In subspecies *b* one morph may become fixed, in ssp. *c* the other, while ssp. *a* retains the original polymorphism. Even if *a* later becomes extinct, the dissected polymorphism (Bowden, 1970)

is still traceable in *b* and *c*. This must have been a common sequence for the differentiation of characters of slight as well as of marked adaptive significance. Ford (1945a: 83) quotes the striking case of the arctic fox, *Alopex lagopus* L.

In the sulphurea polymorphisms of *A. napi*, the alleles (four if one includes the near-extinct bright yellow) probably became established by three successive dimorphisms of this kind, though one cannot yet determine their order.

There is of course a general if not universal condition for the maintenance of polymorphism (while it lasts), that the population over a period should be at least as viable with two morphs as it would be with either alone. When the morphs have become fixed in allopatric populations or even distinct species, it seems that at some time and place this condition has ceased to be satisfied.

But this overlooks some consequences of the variation within the precursor population. Since its genotype is not uniform, the samples taken from it to produce *b* and *c* will have differed, and if these founder populations have been small, either originally or in subsequent fluctuations, some genes included in *a* may not be represented at all in *b* (or *c*). Moreover, as May (1976) reminds us, replicate lines from the same initial population, kept in identical conditions, can reach very different limit-compositions, as a result of statistical accidents early in the breeding program.

The so-called fixation of one morph theoretically does not involve the permanent elimination of the other, even in a single population. Recurrent mutation may be expected to cause its persistence as the heterozygote at a very low fluctuating level, even if with intermissions. It might seem that this could permit the reconstitution of the polymorphism if selection-pressures came to favor it, or even the evolution of a new genotype around the temporarily rare allele. But the chance of this must steadily decline and finally vanish.

The irreversibility of evolutionary changes was postulated by Meyrick (1884), though apparently only for changes of generic or higher rank. Muller (1939) already concluded, "The determination of the exact mutational path of evolution involves a large element of accident and . . . this path can never really be retraced, nor paralleled, in a second evolutionary sequence, nor can the same complex genic system be twice arrived at." At any level, the principle follows from the mutual dependence of genes in their operation. As a mutant at one locus proceeds towards fixation, other parts of the genotype undergo changes, so that a simple reverse mutation no longer restores the original condition. For true restoration a series of reverse changes must take place in the correct order—with

probability approaching zero. An evolutionary event is reversible: an evolutionary history is not (Dobzhansky, 1970). Thus I believe that lost characters are rarely restored, and perhaps never with quite the original genetic mechanism.

While our precursor species remains intact, we have a number of individuals, occupying the same niche, in competition. But if *b* and *c* are separated geographically, interbreeding ceases and so does reproductive competition. The two daughter gene-pools evolve along separate historical successions, genotypes in *b* now competing only with other *b* genotypes; whether *c* has evolved "superior" genotypes is irrelevant. Thus it is not certain that *b* and *c* are both better adapted in their own locations: it is possible that they would do equally well if interchanged.

Species appear to have been free to make a wide range of replies to the same ecological demands. It is remarkable how different organisms in the same habitat, and even in practically the same niche, utilize such diverse means of "adaptation" to it (thus of course modifying the niche). The strength of their defense against the selective tyranny will be appreciated more readily by the botanist (Willis, 1940; Gavaudan, 1967; Stebbins, 1974) than by the zoologist, who is tempted to endow his mobile subjects with niches of any complexity that his theories demand. "Within any gene-pool there exist several . . . alternative gene combinations that might adapt the organism to any new environment. The particular adaptive combination that will become established will depend largely upon the nature of the gene-pool already present" (Stebbins, 1974). If a population could be divided *equally* between two separate identical biotopes, it is probable that even then two identical subspecies would not be formed.

Only in its marginal habitats is the adaptation of a species critical for its survival. Butterflies are able to accomodate variation in the reproductive success of the "same" population by factors of ten or twenty to one (much larger fluctuations have been quoted for other organisms); beside such ratios selective advantages of even five or ten percent related to a particular imaginal character (even fertility) are quite insignificant **if they apply between separated populations**. This does not mean that, within each, selection does not still act on the character—merely that the apparent alternatives are not in competition, if the taxa concerned are no longer interbreeding. Allopatric differences cannot be maintained by selection between them.

The relative stability of a subspecific genotype results from its achievement of an adaptive peak, almost any small departure from which will involve disadvantage. In a widespread species there are many such peaks, and although some are "higher" than others, a particular population will

normally be unable to pass from one to another. Only where a cline exists peaks are not separate but form, as it were, an elevated ridge, allowing free variation in the clinal character.

In any one environment, at any time, there may be several adaptive peaks accessible to a population. Once it is on a slope, selection will drive it upwards, but it cannot climb two separate peaks at once unless it is no longer panmictic. The initial difference which determines the peak to be climbed is at that stage probably nearly neutral.

Nor does the peak genotype's integration imply that any one character has optimum individual adjustment. This is clear enough where distinct "island" subspecies occur in the same climatic region; examples are well known in *Erebia* (Satyridae). In that genus the different wing-patterns may tell us something about past relationships, but very little about present ecology.

"Les corps inanimés ne dependent pas du temps. Les corps vivants lui sont indissolublement liés. Chez eux, aucune structure ne peut être détachée de l'histoire" (Jacob, 1970). Whatever is, is good—but it may not be the best.

Origins, Range-changes and Hybridization

In recent years systematists (e.g. Brundin, 1972; Darlington, 1970; Croizat *et al.*, 1974) have been debating newly formulated ideas on biogeography. The accepted view, deriving originally from Darwin, had been that a species arose at a particular place and if successful spread therefrom. Adams (1902) provided criteria for the determination of centers of origin, the most important being the "location of the greatest differentiation of a type." Matthew (1915) deduced that the most advanced species would be found at the center of origin and the most primitive or conservative in peripheral areas. However, Hennig's (1966) "phylogenetic systematics," sometimes identified with cladism, implies that speciation is always by division of a pre-existing species-stock (e.g. by geographic catastrophe) to produce vicariant populations which then evolve separately in their own areas: these are recognizable as belonging to one monophyletic group by their common possession of derived ("apomorphic") characters. One of Hennig's rules states that species with the most primitive characters are found in the area earliest occupied by the group—thus contradicting the formerly accepted view.

Some of the contestants approached bigotry in their philosophical discussions, and the subject can now be advanced only by consideration of particular examples.

Too little is yet known about *Artogeia*. Using Adams' criterion, the

genus was given an origin in central Asia, and writers such as Müller & Kautz (1939) supposed that species and subspecies spread therefrom to the north, west and east, reaching North America via the Bering area. These taxa, then, differed even at the start of their journeys and retained their characters long after arrival. On the other hand, Hennig-Brundin principles would suggest that, while any secondary characters held in common are evidence of common descent, the characters distinguishing the subspecies arose only in the various localities after contacts were interrupted, and represented the results of local adaptation.

Both alternatives are too simple. The evolution of *Artogeia*, in Pliocene and Pleistocene times, has been complicated by relatively rapid alterations of climate and by fluctuating sea levels affecting the extent of exposed ice-free land. Time-scales are such that, in many if not all cases, territories must have changed since the differentiation of the taxa—a process almost indistinguishable in its results from conventional dispersal. One has to suppose that major continental drift in the Atlantic area occurred too early to affect *Artogeia*, but some seas, and some mountain ranges, are younger.

Even in a region as small and well-known as the British Isles, there is still some uncertainty about the relationships of the populations of *A. napi*. Its position is simpler than that of *Aricia agestis* Denis & Schiffermüller/*artaxerxes* Fabricius (Høegh-Guldberg & Jarvis, 1969), in that it is unnecessary to propose any specific separations, but there are parallelisms. Verity (1911, 1916) placed the dark-female butterflies of Ireland and Scotland in his ssp. *britannica*, while naming those of England as ssp. *septentrionalis*. Warren (1968) took the Scottish populations (but not the Irish) as belonging to the "species" *adalwinda*, and named them ssp. *thomsoni*; his view was based on a strange argument concerning their androconial scales. In 1970 Lees recorded the existence of a univoltine race in Yorkshire at about 300 m elevation. Thomson (1970) found that androconial *thomsoni* extended as far south as Yorkshire, but was everywhere at least partly bivoltine.

An adequate discussion would be out of place here. There seems little doubt that the Irish and Scottish populations, which regularly include ochreous females and darkly marked ones, derive partly from *adalwinda*-like insects which occupied the Channel area during the last stages of the Würm (Wisconsin) glaciation. In the short post-glacial period *A. napi* has invaded Britain from the South and its introgression has progressed so far that in southern England the modern ssp. *septentrionalis* hardly differs from the nominotypical subspecies. Even in Scotland there are probably now no pure relict "*adalwinda*." Indifferently as to whether they carry subarctic genes or not, all members of the Scottish

demes are adjusted physiologically to their present biotopes. Where and how the original separation of *napi adalwinda* and *n. napi* took place is quite unknown.

In North America, mountains made conditions complex during the retreat of the ice, and true relict populations may exist—ssp. *marginalis* and perhaps *macdunnoughii*?

Even in the last ten thousand years or so insects whose predecessors were separated at much more remote periods have come into renewed contact while still interfertile. The resulting zone of secondary intergradation (Mayr, 1942) is commonly marked by a proliferation of forms in unstable polymorphisms. The instability is long-period and so cannot be established with certainty. Probable examples are to be found in the *Artogeia* "subspecies" *flavescens* Wagner and *neobryoniae*; the zones of introgression are quite deep, suggesting that the gene-complexes of the original constituent races were basically similar. Indeed without such similarity the gene-expression might be disturbed (Kettlewell, 1965, 1973). Variation in chromosome number within a population, as in *A. (n.) neobryoniae* (Lorković, 1970) may or may not lend support to the hypothesis of hybrid origin, but the significance of B-chromosomes in the *A. napi* group is still uncertain.

Warren (1966-69) has derived many apparently normal *Artogeia* species or subspecies from processes of hybridization (necessarily in secondary contacts). As he writes, we have for example *oleracea* and other Nearctic subspecies taking their origin from *A. narina* Verity \times *A. dulcinea* Butler (Warren, 1968). These supposed parent species must be understood as ur-*narina* and ur-*dulcinea*, because they may since have undergone as much change as the "hybrids" evidently have. If we reject Warren's unsatisfactory androconial criterion of hybridism (Bowden, 1971) there is no obvious reason to exclude the possibility of an ur-*oleracea* contemporary with the precursors of *narina* and *dulcinea*. Hennig (1966) seems to take the view that when a new species has split off from an existing stem-species, the stem-species also must be taken as changed. I am not sure that this will always be so, when new species are formed from peripheral subspecies. Nor is the possibility of reticulate evolution (i.e. close hybridization) to be altogether excluded: there may sometimes have been more than contact-line introgression. We should try to infer phylogenies for our species from the evidence that we can collect, but a large element of conjecture will have to be tolerated.

The Alaskan *A. (n.) passosi* Warren may well be the *oleracea* \times *hulda* hybrid that Warren (1968) supposes, though not reproductively isolated from either *oleracea* or *hulda*. In the secondary contacts of the *napi* populations of Scandinavia, the British Isles and southern Europe

the distribution of characters in the conjoined populations has perhaps become clinal, with no definite limits to the mutual introgressions. If the characters are adaptive or have become linked to adaptive ones, local optimization may control the proportions of the morphs in a frequency-cline, but otherwise recognizable distinguishing characters reflect origins rather than adjustments to the varying environment. Stepped clines may be better considered as arrays of micro-subspecies, unless appropriate partial barriers can be found located at the steps. See, however, Endler (1977).

Ford (1949) treats British *Coenonympha tullia* populations as a presently interrupted cline, and postulates some flow of genes between many of them even today, but in fact his Merioneth \times N. Scotland crosses showed disturbances almost too great for a mere cline of 700 km. Even a continuous cline, with its assumed equilibrium conditions, may not always be distinguishable from an historical pattern originating from range-change by differing routes.

Clarke (1970), commenting on the Cornish boundary phenomenon in *Maniola jurtina* (Creed *et al.*, 1959), suggested that two races of the species might have been involved, though Ford (1975) rejected this view with extreme scorn. Nevertheless, an "area effect" (Cain & Currey, 1963), of adaptation to inherited genotype rather than to external ecology, may indeed be operative.

CONCLUSIONS

Special

1. There is no evidence that the difference in *Artogeia napi* between narrow American underside veining and broader European veining is adaptive. Both crypsis and optimum radiation-absorption can be secured with either arrangement of black scales.

2. In the "summer" emergence of various subspecies there may be adaptive adjustment of the degree of underside blackening for the most favorable balance between cryptic and thermoregulatory functions.

3. The subtalba polymorphism, controlling production of sepiapterin or failure to produce it, is dissected in the *Artogeia napi* species-group. In certain populations, particularly in the alpine regions of the Old World, the polymorphism is a balanced one, at least on a medium time-scale. Though proportions of the morphs vary locally, no ecological basis is yet known and explanations may be historical.

4. Form subtalba may have reached the *bryoniae* butterflies from an *ur-melete* or related Asiatic taxon, but if so changes have since occurred in its genetic control.

5. Other alleles at the sulphurea locus will repay further study in a wider range of populations in the three continents concerned. The pale yellow forms are stabilized in at least one (probably relict) subspecies.

6. The significance of the *bryoniae* female marking remains uncertain. The taxa carrying it were in the past conspecific with other branches of the *napi* stem. Müller & Kautz (1939) considered it beyond question that these taxa represented the conservative (even archaic) descendants of the Pliocene, probably subtropical, insect. This is no more than conjecture, but not unreasonable; if it is correct, what we have to account for are not the dark females but the white males of *bryoniae* and both sexes of *napi*.

7. *Artogeia* adults are cryptic at rest, probably aposematic in flight. Local differences in pattern may be irrelevant in both respects.

General

8. Overt differences between allopatric populations of the same species or species-group need not be supposed in every case to have any present adaptive significance. Some varying characters shown in the course of a life cycle may be well adapted to the habitat, but many are approximately neutral. Competition between their holders can only be internal to a population. The central weakness of the extreme selectionist position may lie in its assumption that a determinable fitness is associated with any particular gene.

9. The permanence of subspecific characters (and still more of specific) depends on their tendency, once fixed in the genetic sense, to become irreversible in practice.

10. Characters that are now nonadaptive may have been evolved at a remote period in a locality far removed from the present habitat. Biogeography is not merely a branch of ecology. Ecological fallacy results from treating populations as stationary objects of local selective pressure; instead, they should be allowed a more active role, with every evolutionary quasi-random "choice" determined in some degree by the influence upon the genome of previous choices. The saying "Evolution always occurs somewhere else" is nearly true.

11. When the "same" character arises independently in two stocks by parallel evolution, parallelism will probably be incomplete and a genetic difference can sometimes be found, to alert the investigator.

12. Otherwise, the common possession of the same "nonadaptive" characters permits tentative conclusions on phylogenetic relationships. The barrier to the reversal of a genetic change is an increasing one,

allowing the established form to be taken as indicator (though not as final proof) of the affinity of subspecies which possess it.

13. Discontinuities of pattern-distribution can often be used to delimit demes whose past histories have not coincided.

14. Genetic histories do not repeat themselves, whatever the ecological pressures.

Murray (1972), discussing the work of Kimura & Crow and others on electrophoretic alleles in *Drosophila*, etc., says: "There are loci which are monomorphic in all populations, there are loci with rare variants, and there are loci which so variable that no 'wild type' can be identified. However, there is a kind of differentiation that is conspicuously absent, i.e. a pattern of variation with the fixation of different alleles in different localities. This last pattern is the expected outcome of allelic neutrality."

Publications on the allozymes of *Artogeia* are awaited. But is this missing pattern not to be found in the visible characters of this group?

In one sense, all important characters of the *napi* group are adaptive, and are maintained by soft selection (Wallace, 1968). But the visible differences between the various taxa, with which this paper has been concerned, are not primarily adaptations to the present environments but derive from historical "accidents" affecting neutral or nearly neutral polymorphisms in the distant past. As far as can be seen, there has always been more than one way forward for a subspecies. Even under strong selective pressures there are alternatives, and each option taken modifies the choices which will be presented in the future.

ACKNOWLEDGMENTS

I am indebted to an anonymous referee and to Dr. Bryan Clarke for valuable criticism of earlier versions of this paper.

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NOTES ON THE LIFE CYCLE AND NATURAL HISTORY OF BUTTERFLIES OF EL SALVADOR. III C. *HISTORIS ODIUS* AND *COEA ACHERONTA* (NYMPHALIDAE-COLOBURINAE)

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ABSTRACT. A complete photo-illustrated report on the early stages of *Historis odius* (Fabricius) and a partial of *Coea acheronta* (Fabricius) are presented, which reveals similarities between the two species suggesting a very close relationship. Both species utilize the same foodplant in El Salvador, *Cecropia mexicana* (Moraceae), whose close relative, *C. peltata*, has been reported as foodplant in Brazil by some authors under the vernacular name "Embauba." The placement of these two species in the Coloburini is questioned and some striking larval similarities with *Smyrna blomfieldia* and *S. karwinskii* (both also questionably placed in the Coloburini) and with *Pycina zelis* (placed among the Vanesiini) are pointed out. Larvae of *Historis odius* are subject to heavy parasitization mostly by tachinid flies and one case of nematode parasitization, (*Mermis* sp.), is recorded. *Historis odius* is by far more abundant in El Salvador than *Coea acheronta* and covers a wider range of altitudes.

This article presents information on the life cycles and natural histories of the two largest species of butterflies included in the Coloburini: *Historis odius* (Fabricius) and *Coea acheronta* (Fabricius).¹

The first time we saw the eggs of *Historis odius* was 6 October 1970 when our good friend Viktor Hellebuyck captured and papered a female. Some 15 eggs were deposited by the female while still alive inside the envelope. The only information we had at the time about the foodplant of the larvae of *H. odius* was a name found in Seitz (1920) and later repeated by Ehrlich & Ehrlich (1961): "Embauba." Knowing the hosts of related species, we placed some of the eggs of *H. odius* on the foodplant of *Colobura dirce* (L.), *Cecropia mexicana* Hms. (Moraceae), and some on the foodplant of *Smyrna blomfieldia* Fabricius and *S. karwinskii* Hübner, *Urera caracasana* (Jacquin) Grisebach (Urticaceae). In due time the eggs hatched and the larvae placed on *Cecropia* ate it for three days but then died, while the ones on *Urera* all died without feeding. Since then we have been able to rear the species several times from eggs and larvae collected in the field, on *Cecropia mexicana*.

Coea acheronta has proven to be more difficult. In 18 years of collecting in the country, only one adult has been captured and only one larva has been collected. The larva was taken in the fifth instar on *Cecropia mexicana* also and reared to adult.

¹ Specimens of eggs, larvae and pupae of *H. odius* were preserved in alcohol as were the larval skin and pupal shell of *Coea acheronta* and were sent to the Allyn Museum of Entomology, Sarasota, Florida, USA.

LIFE CYCLES

Historis odius

Egg (Fig. 1). Spherical, light brown with 23 lighter vertical ribs, armed with thin spinulets or thick, short setae running from base of egg to $\frac{3}{4}$ of the side where they merge into a circular arrangement of two rows of hexagons, leaving a large octagon around micropyle. Diameter ca. 1.5 mm. Hatches in 5–6 days.

First instar larva (Fig. 2). Head dark brown with sparse setae. Body cylindrical, gray before feeding, olivaceous afterwards, with transverse rows of thin, short, light setae. Ca. 3.5 mm long. Moults in 3–4 days.

Second instar larva (Fig. 3). Head dark brown, surrounded by a row of short, lateral spinulets and short, thick epicranial horns armed with rosette of short spines distally. Body dark brown with whitish transverse markings on thoracic segments, white spots subspiracularly from 1st to 5th abdominal segments and white transverse stripes caudad. Short white scoli with light spines, furcated distally, on all segments except 1st thoracic. Ca. 8–9 mm long. Moults in 3–4 days.

Third instar larva (Fig. 4). Head squarish with indented epicranial suture, low triangular frons with no visible adfrontal areas. One spine standing at each side of superior end of epicranial suture; a short, thick, rough-surfaced horn on each epicranium. Each with terminal rosette of short spines: two directed forwards, two backwards and one vertical; lateral row of spines diminishing in size down to ocelli; another spine frontally, another slightly lower and a final one at center of the arch of the ocelli. Color is variable: either all dark brown or dark brown with orange spot under epicranial horns and another around ocelli. In the latter case, spines on head capsule and tips of horns are also orange. Body ground color dark brown, masked thoracically and from 6th abdominal segment caudad by transverse whitish stripes. Scoli and spines whitish also. Spine arrangement: 1st thoracic (T-1) with dark cervical shield having subdorsal scolus with two terminal spines and dark spiraculum having one simple spine above and slightly behind; T-2 and T-3 with 5-furcate subdorsal scolus, simple supraspiracular spine very close to anterior border of segments, one bifurcate supraspiracular scolus and one simple subspiracular spine. First abdominal segment (A-1) with one dorsal 4-furcate scolus, one 4-furcate supraspiracular scolus; 2-furcate scolus and a simple spine anterior to spiraculum. A-3 to A-7 as A-2 but lacking subdorsal scoli. A-8 with two dorsal scoli, two supraspiracular scoli, one simple spine and one 2-furcate subspiracular scolus. A-9 with one supraspiracular 5-furcate scolus directed backwards. A-10 with 2-spined anal fork. All scoli and spines light yellow except orange dorsally from A-2 to A-6. Grows to 17 mm in 5 days.

Fourth instar larva (Fig. 5). Head as in third instar but larger. Body ground color brown with transverse whitish stripes on all segments, ventral surface reddish. Grows to 38 mm in 2–4 days.

Fifth instar larva (Fig. 6). Head about 8 mm wide, same colors as in third instar. Body with white or light yellow stripes on red ground color. Scoli reddish on white-striped morph, yellowish on yellow-striped morph. Ventral surface reddish or orange. Spiracula and anal fork, black. Grows to 70–72 mm in 6–7 days.

Prepupa. Slight general discoloration and reduction in length. Duration one day.

Pupa (Figs. 7–9). Lateral aspect: very flat, abdominal 10, 9 and 8 thickening abruptly to A-7 then gradually to A-3 (thickest part of body), with indentation on A-1 to T-3, then humping dorsally on T-2 then reducing to head, which terminates with two round, dorsally incurved, partially apposed cristulae about 10 mm long. A-1 with dark wart at meson, another subdorsally and one supraspiracularly. From A-2 to A-7 one dorsal 4-furcate spine, one supraspiracular dark wart, and from A-3 to A-7 another spiracular wart. Cremaster located ventrally on a peculiar formation on the last abdominal segments. Ventral aspect: abdominal segments thicken bluntly from cremaster, about the same width up to wingcases, which are slightly thicker

up to about head level; angles abruptly narrowing to the root of head cristulae. Color pinkish brown with black-tipped, reddish spines and red rings around cristulae. Dimensions: 50 mm long, 13 mm dorsoventrally, 12 mm laterally at widest points. Adult emerges in 10–14 days, females being slower than males.

Adults (Figs. 10–13). No noticeable sexual dimorphism. Forewing with convex costal margin, with projected angled apex, S-shaped outer margin to round tornus, straight inner margin. Hindwing with slightly convex costal margin, rounded outer margin to somewhat acute anal angle; inner margin with strong fold. Dorsal color on forewing, orange basally with black border from mid-costal margin to apex, descending to tornus, then back to mid-inner margin forming a rounded dark area. White subapical spot close to costal margin. On hindwing the basal orange is strongly reduced, the rest being dark brown with a light brown thin border along outer margin. Ventral color of both wings, mostly light brown with black lines parallel to body. No “eyes” present. Subapical white spot also visible on underside. Body concolorous to respective dorsal and ventral colors of wings. Eyes and antennae reddish-orange. Wing span varying from 75 to 90 mm, females usually larger than males. Total developmental time, 36–45 days.

Coea acheronta

Fifth instar larva (Figs. 14–15). In all respects like *Historis odius* except for the color. Head basically red with black horns and an irregular spattering of black spots of various sizes. Body mostly dull black with three saddle-like yellow markings extending to subdorsal area on abdominal segments 2, 4 and 6. A broken brown band along spiracula sprinkled with tiny white dots. Spines arranged as in *H. odius*, of light color on scoli concolorous to body zones. Spiracula black with light brown borders. Ventral surface white. Single specimen grew to 65 mm.

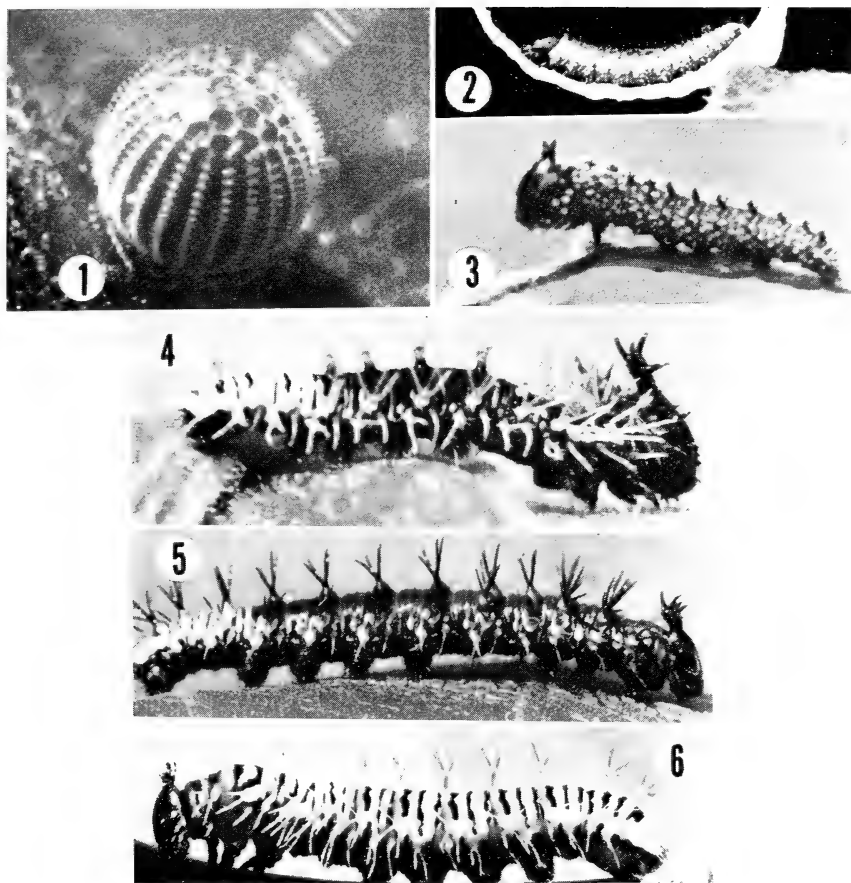
Prepupa. No color change. Lasted for one day.

Pupa (Figs. 16–18). Very much like *H. odius*, the only differences are the size and relative position of head cristulae, which are shorter, not incurved or apposed, but slightly divergent. Total size about the same as *H. odius*. Adult emerged in 9 days.

Adult (Figs. 19–20). Same color pattern dorsally as *H. odius* with five additional white spots on forewing from mid-costal margin to mid-outer margin, and a black spot on hindwing near anal angle. Differences in shape are noticeable; apex not projected, but rounded, smoother outer margin, small tail continuing M_3 vein of hindwing. Antennae orange with black tip. Wingspan 80 mm.

NATURAL HISTORIES

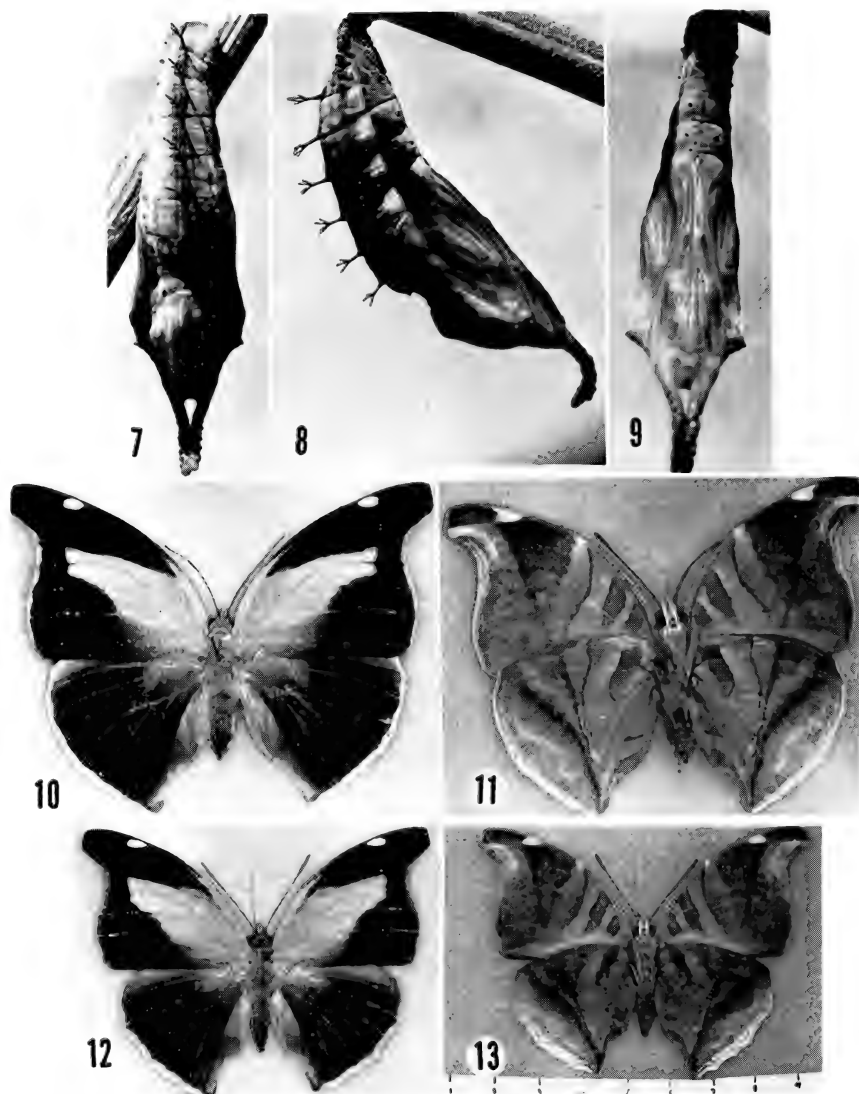
Most of our observations on the early stages and adults refer to *Historis odius* although what we have learned about *Coea acheronta* corresponds very closely. The adults are large, robust, pugnacious and fast flying. Males exhibit very strong territorial defense behavior. They perch on tree trunks, usually on hilltops, and chase any intruding flying insect as well as birds. At times several conspecific males favor the same area, leading to “ritual fights” between two or more males. We call them “ritual fights” because the opponents seldom, if ever, actually come in contact in their rapid circumvolutions even when there are many males involved. This kind of fighting we have noticed also in many other species even not related to *Historis*: *Phoebis* spp. and *Hamadryas* spp., with the



Figs. 1-6. *Historis odius*: 1, egg, ca. 1.5 mm diameter; 2, first instar larva, ca. 3 mm long, resting on perch; 3, second instar larva, ca. 8 mm long, on bared vein; 4, third instar larva, ca. 15 mm long; 5, fourth instar larva, ca. 38 mm long; 6, fifth instar larva, ca. 72 mm long.

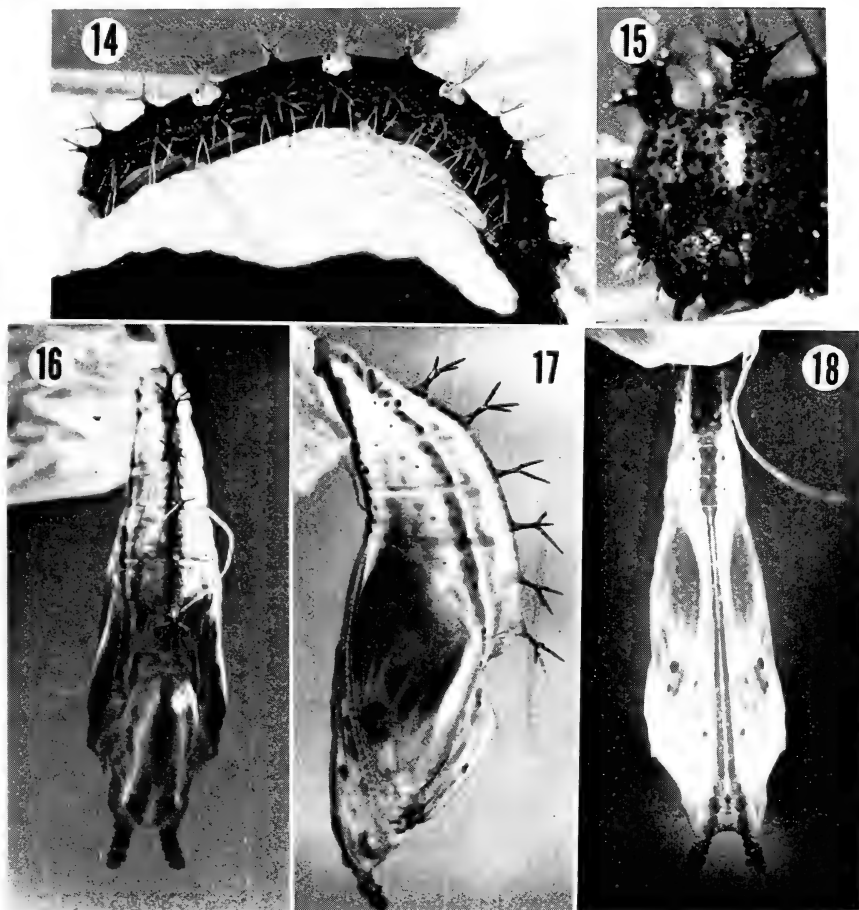
additional "clicking," and many *Lycaenidae*. These fights end when one or more of the rivals tires and returns to their perching trees. At times there are males of different species perching in the same area. Usually there is no interaction unless one of them flies over another perching male. In such cases, the intruder is chased and flies back to his perch without any resistance.

H. odius, males in particular, are attracted to mud puddles, fermenting fruits (either on the ground or even while still on the tree) and to sap oozing from tree wounds. We have never seen them on any kind of excrements. At times they come to rest on humid roadsides or ravines.



Figs. 7-13. *Historis odius*: 7, pupa, dorsal aspect, 50 mm long; 8, pupa, lateral aspect; 9, pupa, ventral aspect; 10-11, female, dorsal and ventral aspects, 90 mm wingspan; 12-13, male dorsal and ventral aspects, scale in cm.

Females ready to oviposit, visit mid-sized *Cecropia* trees, alighting on mature leaves, usually on the underside, and repeatedly act as if depositing an egg without actually doing it. It is after several such performances that they drop from the underside of a leaf to the upper surface of a



Figs. 14-18. *Coea acheronta*: 14, fifth instar larva, 65 mm long; 15, close-up of larval head; 16, pupa, dorsal aspect, 48 mm long; 17, pupa, lateral aspect; 18, pupa, ventral aspect.

lower one. There the female deposits a single egg, always in the central area of the leaf. Several eggs might be thus deposited on the same tree, but never on the same leaf.

The newly hatched larva eats the upper part of the shell, down to the lateral ribs, leaving the rest untouched, and then crawls to a border of the leaf. It starts feeding at the end of a vein, usually at the tip of a lobe, and bares the vein while constructing a resting perch with frass pellets agglutinated with silk. Unlike other species that make resting perches, *H. odius* leaves the perch naked, without hanging pieces of leaf tissue



Figs. 19-20. *Coea acheronta*: adult, dorsal and ventral aspects.

from it. During the first instar the larva may drop from the perch when disturbed, but is able to return to it by means of a silk thread that it produces while falling, as is done by many larvae of Heterocera. First, second and third instar larvae stay all day on the perch, moving from it only to feed. In this respect they behave differently from all Limenitidinae, which stay on the perch while feeding so that the bared vein by the perch is extremely long and has a barrier of dry bits of leaf tissue all around the eaten portion. *H. odius* may make more than one perch during the first three instars, but uses one after the other.

The perch is abandoned starting with the fourth instar and the larva rests

conspicuously on the upper surface of the leaf, which suggests that the species may be protected against predation by the foodplant components. The larva may also be protected by its sharp spines even though these do not have stinging properties. The larvae of *H. odius* are subject to parasitization, mostly by tachinid flies. We found one larva that was killed in the fourth instar by a parasitic nematode, *Mermis* sp. The nematode was many times longer than the larva (ca. 170 mm versus 31 mm).

When ready to pupate the larva of *H. odius* wanders about the plant until a leaf or stem is chosen; it weaves a silk pad. The larva attaches thereon its anal prolegs and hangs for a day with head and thorax ventrally incurved after voiding its digestive tract. The large, conspicuous pupa hangs freely from its cremaster and reacts vigorously to the least provocation with lateral wiggings. It has no protective coloration or shape as does *Colobura dirce* (Muysshondt & Muysshondt, 1976).

The adult emerges rapidly from the pupal shell and hangs from it while expanding its wings and ejecting a rust-colored meconium. Some 45 min later the butterfly is ready to take flight. The energetic and extremely fast rustling flight of *H. odius* is very similar to *Prepona* and *Archaeoprepona* spp.

The foodplant, *Cecropia mexicana*, is discussed in our paper on *Colobura dirce* (Muysshondt & Muysshondt, *loc. cit.*). *Historis odius* is found from sea level to about 2000 m elevation, the same as *Colobura dirce*. *Coea acheronta* occurs from 800–1200 m.

DISCUSSION

The generic name *Historis* was established by Hübner in 1819 with *Papilio odius* Fabricius as the type-species. *Coea* also was created by Hübner in 1819 with *Papilio acheronta* Fabricius as the type-species. According to Hemming (1967) both genera are valid. Yet there are several authors (e.g. Smart, 1975; Riley, 1975; Barcant, 1970; Brown & Heineman, 1972; Ehrlich & Ehrlich, 1961) who place *odius* and *acheronta* in *Historis*. Still others, old and modern (e.g. Lewis, 1974; Seitz, 1907–1924; Schatz, 1885; Reuter, 1896; Doubleday et al., 1849) place the two species under separate genera with the complication that some use the generic name *Aganisthos* Boisduval & LeConte for *Historis* and *Megistanis* Doubleday for *Coea*! According to Hemming (1967) *Aganisthos* was established in 1834 with the type-species being *Papilio orion*; however, *orion* and *odius* are now considered conspecific. From the same source we see that *Megistanis* was established by Doubleday in 1844. Its type-

species is *Papilio cadmus* Cramer, which is the same as *acheronta*, yet the name *Megistanis* is also valid.

The similarities we have found in the early stages of *odius* Fabricius and *acheronta* Fabricius suggest that both species are congeneric, regardless of the evident differences between the adults. However, we leave the resolution of such matters to the taxonomists.

Doubleday *et al.* (1849) compared *Historis* (as *Aganisthos*) with *Siderone* and *Prepona*, yet he considered *Coea* (as *Megistanis*) to be the "American representative of the typical Nymphales." Boisduval (1870) stated: "Ce genre est bien voisin des *Prepona*, dont il ne differe guere que par la forme des ailes. Les chenilles, d'après le dessin que nous avons vu, sont tout-à-fait semblables." (This genus is closely related to *Prepona*, the only difference being the wing-shape. The caterpillars, as per a drawing we have seen, are completely alike.) This statement is far from reality as can be easily seen by comparing the illustrations in this article with those in our papers on *Prepona omphale octavia* (Muyshondt, 1973) and *Archaeoprepona demophon centralis* (Muyshondt, 1976).

The early stages of *H. odius* have been at least partially described as early as 1886 (Müller) from some drawings made by Burmeister (1878) of a larva and pupa. Also accordingg to Müller, Dewitz reported the foodplant to be *Cecropia peltata* L. Stoll (1791) presented the drawing of a *Historis* larva thinking it was an *Anaea*. In modern publications there are some sketchy descriptions (Hayward, 1931; Howe, 1975; Riley, 1975) and one more elaborate (Brown & Heineman, 1972) that in some respects matches our own. Hayward (*loc. cit.*) mentions "*Embauba*" (as a genus!) as the foodplant of *Historis*. Of *Coea acheronta* there is only an assumption made in Brown & Heineman (*loc. cit.*) of a larval and pupal description made by Wolcott based on information received from E. G. Smyth. Riley (1975) mentioned the same thing. Ours seems to be the first complete, illustrated description of *Historis odius* and the only account (admittedly incomplete) of *Coea acheronta*.

Comparing the early stages of these two species with the early stages of the other local species currently included in the Coloburini, we see that there are hardly any points in common with *Colobura dirce* (Muyshondt & Muyshondt, 1976) except for the use of the same foodplant. Compared with *Smyrna blomfildia* and *S. karwinskii* (Muyshondt & Muyshondt, 1978) they show superficial resemblance during the larval stage, but not as eggs or pupae. Both *Smyrna* use Urticaceae, not Moraceae, as foodplants. The early stages of *Pycina zelis* Godman & Salvin resemble those of *Historis odius* and *Coea acheronta* more than *Smyrna*. The egg is about the same size and has the same shape but a different number of ribs (32 in *Pycina* versus 23 in *Historis*); the larva

also has the same general aspect but different coloration. Although the pupa of *Pycina*, according to drawings supplied by Dr. A. H. B. Rydon of pupal shells at the British Museum (Natural History), is not like *Historis*, *Pycina* adults do have the same color pattern dorsally as does *Coea acheronta*, the underside being more like *Smyrna*. *Pycina zelis* feeds on Urticaceae as does *Smyrna*.

The eggs of *Historis odius* and *Pycina zelis* (probably of *Coea* also) have spinulets or setae that are more or less thin. The only other eggs we have seen with setae, even if much thinner, are the eggs of various species of *Adelpha*, *Biblis* and *Mestra*. The shape of these eggs though have nothing in common with the eggs of *Historis* or *Pycina*. *Adelpha* eggs, like all Limenitidinae, are "pineapple" shaped and covered all over with hexagonal cavities. Eggs of *Biblis* and *Mestra* are slightly cone-shaped with vertical ribs reaching close to the micropyle and covered with a profusion of thin setae.

In *Historis odius* we again find the similarity noticed in many other species feeding on plants reputed to be poisonous or at least containing noxious or strongly aromatic compounds; the larvae wander openly on the leaves of the foodplant and have gaudy colorations that suggest unpalatability or some other type of protection against predation. The adults also have showy color combinations, at least dorsally, many including orange, a color that has been associated with predator-deterrent properties in insects. Yet these larvae are heavily decimated by parasites, especially Diptera and Hymenoptera. Interested readers may refer to Muysshondt (1974 & 1975) for our hypothesis regarding the preference of parasitic Diptera and Hymenoptera for hosts protected from predation by foodplant derivatives. Regarding the parasitic nematode, *Mermis* sp., the only other time we personally found it affecting lepidopterous larvae was in 1964 when an early outbreak of *Trichoplusia ni* (Hübner) occurred on cotton in the central area of El Salvador. Many larvae were found dead, still clinging to the leaves, with the nematode abandoning the host through the anus. Then in 1972 our good friend Steve Steinhauser gave us a larva of *Quinta cannae* Herrick Schäffer which produced three nematodes. The nematode was many times longer than the host in every case.

ACKNOWLEDGMENTS

We feel greatly indebted to Dr. G. L. Godfrey for reading, criticizing and suggesting improvements to our article. One of us, A. Muysshondt, Jr., thanks the Zoologische Staatssammlung in München and the British Museum (Natural History) for allowing him to photocopy many old works that

helped us document our presentation. We are grateful to Dr. A. H. B. Rydon for supplying us with several valuable publications for the same purpose.

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BOOK REVIEW

ABERRATIONS OF BRITISH BUTTERFLIES, by A. D. A. Russwurm, 1978. E. W. Classey, Ltd., Park Road, Faringdon, Oxon., England SN7 7DR. 151 pp., including 40 plates. £12.50 (about \$25.00 U.S.).

This is basically a non-technical book of illustrations with annotations. The first 61 pages consist of introductory notes and descriptions of the specimens that are figured in the plates. There are in excess of 300 individual specimens illustrated. Physically the book is well produced with a pleasing format—up to Classey's usual high standards.

Various types of aberrations are discussed in the Introduction, but their origins (genetic, environmental, etc.) are not. The book is basically a "picture book" of selected aberrant butterflies, without scientific basis. The author states, "Deformed or misshapen specimens and other abnormalities . . . are not attractive to the eye and spoil the appearance of any cabinet drawer or coloured plate. They are not illustrated here and we must assume that they belong to a more scientific approach than is claimed by this book."

The author is a fine illustrator and his watercolor renditions of the specimens are well executed and naturally colored. Some specimens are spread in museum fashion, while others are portrayed in natural poses. The spread specimens are shadowed along the right margins, as if being viewed in light coming from the upper left side of the page. I found this feature annoying as it tended to attract the eye away from the specimens.

Although they have no standing with the International Code of Zoological Nomenclature, the author has supplied a "scientific" name and authority for each specimen, with a few exceptions. The exceptions are the use of "ab. nov." without further comment. Of interest is an aberration of *Vanessa cardui*, *varini* Meilhan, that is different from the usual North American aberration, *elymi* Rambur. I have in my collection a *cardui* aberration from southern New Mexico that is intermediate between these two forms.

One does question the reason behind producing a book such as this. It is more of an art book than a scientific book. Perhaps it can be justified on the basis that British lepidopterists have exhausted the more usual taxonomic frontiers. This work will probably have some appeal in England and in Europe, where collectors seem to be more interested in butterfly aberrations than do American collectors. I doubt that it will have much appeal in the U.S. because of the price and the limited geographic subject area.

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REVIEW OF THE MEXICAN *POLYTHRIX* WATSON 1893 (HESPERIIDAE)

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ABSTRACT. Six species of *Polythrix* are listed from Mexico, with a key to their identification, their synonymy, type locality, general distribution, Mexican distribution, and a plate showing the left valve of each species' male genitalia. One name, *Polythrix alciphron* (Godman & Salvin) 1893, is placed in synonymy because that name represents a female form only.

There has been some confusion concerning members of the genus *Polythrix*, particularly in the Mexican area. During the past twelve years I have attempted to clarify the exact generic position and status of members of this genus and their distribution in Mexico and other areas (Freeman, 1967, 1969, 1977). In this article I present a key to the identification of the six species which occur in Mexico. I also list the synonymy of these species, the distribution of each based on specimens in my collection, a brief species description, and a plate showing the left valva of the male genitalia of each species, thus simplifying determination of each species.

Key to the Mexican *Polythrix*

- 1a. No costal fold present 2
- 1b. Costal fold present 3
2. Three apical spots in line; ground color light brown; lower surface of secondaries with dark bands and spots in males, females usually have a broad discal white area; tails in males fairly short (5 mm), in females long (12 mm); discal bands and spots are present on the upper surface of the secondaries but are subdued; head and thorax brown above *octomaculata*
- 3a. Three apical spots present 4
- 3b. Four to five apical spots present 5
- 4a. Head and thorax brown above; discal spots on primaries semi-compact; tails fairly short in males (5 mm), and in females longer (12 mm); discal band on lower surface of secondaries inconspicuous *procerus*
- 4b. Head and thorax brown above; discal spots on primaries compact; tails short, in females (5 mm); discal band on lower surface of secondaries dark and well defined *guatemalaensis*
- 5a. Head and thorax brown above 6
- 5b. Head and thorax green above with intermixed brown scales 7
- 6a. Usually 4 apical spots; discal band not compact; ground color usually dark brownish-black; tails in males medium length (8-10 mm), females longer (15 mm); dark spots in space 1b on primaries evenly colored *asine*
- 6b. Usually 5 apical spots; discal band not compact; ground color usually light brown in coloration; tails in males same length as females (15 mm); dark spots in space 1b on primaries light centered *mexicanus*

7. Four apical spots present; rarely is there a spot in space 1b; tails short in males (5 mm), longer in females (12–16 mm); on lower surface of secondaries space 1b from base to middle deeply grooved and at the distal end of the groove there is a small erect hair tuft on vein 1b ----- *caunus*

Polythrix octomaculata (Sepp) 1848

Synonymy. *decurata* (H.-S) 1869; *calenus* (Mabille) 1888; *elegans* Hayward 1933; *alciphron* (G. & S.) 1893.

Type locality. Surinam.

General distribution. Texas to Argentina.

Mexican distribution. 6 miles south of Ciudad Valles, S. L. P. (Hotel Covadonga), June 1969, ♂ and 2 ♀ (leg. H. A. Freeman); Comala, Colima, 21 Mar. 1967, ♂ (leg. Robert Wind); Salada, Colima, October 1967, 2 ♂ (leg. R. Wind); Acahuizotla, Gro., Oct. 1950, ♂ and Oct. 1955, ♂ (leg. T. Escalante); Dos Amatos, Veracruz, 15 Sept. 1972, ♀ (leg. Ramirez); Catemaco, Veracruz, 18 June 1968, ♂ (leg. H. A. Freeman); Candelaria Loxicha, Oaxaca, March to November, 1968–71, 9 ♂ and ♀ (leg. E. C. Welling); X-Can, Quintana Roo, May 1967, 2 ♂ (leg. E. C. Welling); and Muste, Chiapas, 2 Aug. 1968, ♂ and 30 Oct. 1968, ♂ (leg. E. C. Welling collector).

Remarks. This species has three apical spots of sub-equal size forming a straight line. The discal band is not compact. The spot in space 2 is somewhat square and is situated midway under the larger cell spot. There is a costal spot directly over the cell spot. The spot in space 3 is small and is located outward from the spot in space 2 and the cell spot. There is a faint indication of the discal band on the upper surface of the secondaries; on the lower surface the band is much darker and well defined. The tails are fairly short in the males. There is no indication of a costal fold which Evans (1952) says is characteristic of the genus. Head and thorax are brown above. The female upperside is very similar to the male except the tails are longer. On the lower surface of the secondaries specimens vary from those like males (not having any white) to specimens which represent the type of *alciphron* (Godman & Salvin) in having a large white discal area. Most of the specimens I have examined from Mexico have some white on the lower surface of the secondaries thus indicating that *alciphron* is a female form of *octomaculata* and thus a synonym of *octomaculata* (New Synonymy).

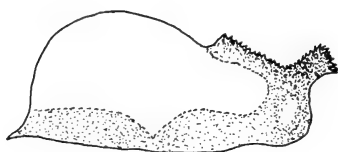
Polythrix asine (Hewitson) 1867

Type locality. Nicaragua.

General distribution. Mexico to Peru.

Mexican distribution. 6 miles south Ciudad Valles, S. L. P. (Hotel Covadonga), June–July 1966–72, 28 ♂ and 14 ♀ (leg. H. A. Freeman); Salada, Colima, May to June 1967, 2 ♂ (leg. Robert Wind); Comala, Colima, April 1967, ♂ (leg. R. Wind); Presidio, Veracruz, July 1951, ♂ and ♀ (leg. Ramirez); Catemaco, Veracruz, Aug. 1965, ♀ (leg. Ramirez); Candelaria Loxicha, Oaxaca, June to Sept., 1968–71, 15 ♂ and ♀ (leg. E. C. Welling); and Muste, Chiapas, June–July 1968, 5 ♂ (leg. E. C. Welling).

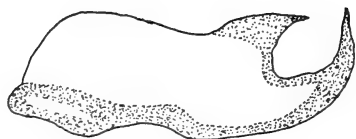
Remarks. Usually 4 apical spots and sometimes 5. The spots increase in size from space 8 to 6. The spot in space 9 is small and if there is a spot in space 5 it also is small. The apical spots form a straight line. The discal band is not compact. The spot in space 2 is fairly small and is usually located somewhat outward from the cell spot, however in some specimens this spot is in line with the cell spot. Spot 3 is over the outer edge of the spot in space 2, well separated from the cell spot. There may or may not be a small costal spot over the cell spot. There are usually two dark spots in space 1b, one under the inner edge of spot 2 and the other basad. The discal bands are prominent on the upper surface of the secondaries; however



1



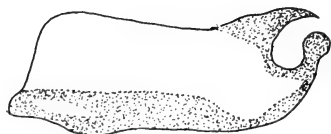
4



2



5



3



6

Figs. 1-6. Male genitalia, left valvae. 1, *Polythrix octomaculata* (Sepp). 6 mi. S. Ciudad Valles, S. L. P. (Hotel Covadonga), 25 June 1969 (H. A. Freeman; H. A. F.); 2, *Polythrix asine* (Hewitson). 6 mi. S. Ciudad Valles, S. L. P. (Hotel Covadonga), 10 June 1966 (H. A. Freeman; H. A. F.); 3, *Polythrix mexicanus* Freeman. Paratype, 6 mi. S. Ciudad Valles, S. L. P. (Hotel Covadonga), 29 July 1966 (H. A. Freeman; H. A. F.); 4, *Polythrix procerus* (Plotz). 6 mi. S. Ciudad Valles, S. L. P. (Hotel Covadonga), 11 June 1967 (H. A. Freeman; H. A. F.); 5, *Polythrix guatemalaensis* Freeman. Holotype, Sayaxche, El Petan, Guatemala, 23 August 1963 (E. C. Welling; A. M. N. H.); 6, *Polythrix caunus* (H-S.). 6 mi. S. Ciudad Valles, S. L. P. (Hotel Covadonga), 10 June 1967 (H. A. Freeman; H. A. F.).

they are usually rather narrow. The tails are usually of medium length; however some specimens have fairly long tails. Costal fold is well developed. Discal and apical spots are white. The general ground coloration is dark brownish-black. Head and thorax above brown.

Polythrix mexicanus Freeman 1969

Type locality. Hotel Covadonga, Ciudad Valles, S. L. P., Mexico.

General distribution. Texas to southern Mexico.

Mexican distribution. 6 miles south Ciudad Valles, S. L. P. (Hotel Covadonga), June–Aug. 1966–72, 31 ♂ and 13 ♀ (leg. H. A. Freeman); Ajijic, Jalisco, 22 Oct. 1965, ♀ (leg. Robert Wind); Catemaco, Veracruz, June 1966–68, 4 ♀ (leg. H. A. Freeman); Juchitan, Oaxaca, 17 Aug. 1964, ♀ (leg. H. A. Freeman); Candelaria Loxicha, Oaxaca, Sept.–Oct. 1968–71, 3 ♂ (leg. E. C. Welling).

Remarks. Usually 5 apical spots with the spots increasing in size from 8 to 6. The spot in space 9 is small as is the one in space 5, which may sometimes be absent. The discal band is not compact. The spot in space 2 is usually midway under the cell spot. There is a small costal spot directly over the cell spot. The spot in space 3 is about half the size of the spot in space 2 and is located over the outer edge of that spot and outward from the cell spot. There are two dark spots in space 1b which are light centered; one is located under the inner edge of the spot in space 2 and the other is basad. The discal bands are well developed above and below on the secondaries and are broader than in *asine*. The tails are long in comparison to any other species of *Polythrix*, particularly in the males. The ground color is light brown. The head and thorax above are light brown.

Polythrix procerus (Plotz) 1881

Synonymy. *aelius* (Plotz) 1881; *auginulus* (Godman & Salvin) 1893.

Type locality. Para, Brazil.

General distribution. Mexico to Venezuela.

Mexican distribution. 6 miles south of Ciudad Valles, S. L. P. (Hotel Covadonga), June 1966–69, 13 ♂ and 4 ♀ (leg. H. A. Freeman); Catemaco, Veracruz (Playa Azul), 12 Aug. 1967, ♂ (leg. H. A. Freeman); and X-Can, Quintana Roo, 2 Aug. 1962, ♂ (leg. E. C. Welling).

Remarks. There are 3 apical spots in this species; the one in space 7 is small and situated slightly inward from the ones in spaces 6 and 8. The discal spots are semi-compact and are sordid white. The spot in space 2 is well developed and is in line with the cell spot. In all my specimens except the male from X-Can, Quintana Roo, there is a small spot in space 1b situated at the outer edge of spot 2. The spot in space 3 is small and in line with the outer edge of the spot in space 2. There is only the slightest indication of a discal band on the upper surface of the secondaries and on the lower surface the discal band is present but inconspicuous. The costal fold is well developed. Head and thorax above brown.

Polythrix guatemalaensis Freeman 1977

Type locality. Sayaxche, El Petan, Guatemala.

General distribution. Southern Mexico to Guatemala.

Mexican distribution. X-Can, Quintana Roo, 26 July 1962, ♀ (allotype), (leg. E. C. Welling).

Remarks. There are 3 apical spots in this species; the one in space 7 is smaller than the ones in spaces 6 and 8 but in line. The spots that form the discal band are sordid white and they are compact with a well developed spot in space 1b, a somewhat square spot in space 2, an elongated cell spot, a costal spot of about the same width as the cell spot, and a triangular spot in space 3 which is against the spot in space 2 and the cell spot. There is only the slightest indication of a discal band on the upper surface of the secondaries; however on the lower surface this band is dark and well developed. Costal fold is well developed. The tails are comparatively short in this species. The head and thorax above brown.

Polythrix caunus (Herrich-Schaffer) 1869

Synonymy. *lindora* (Butler) 1870.

Type locality. Unknown.

General distribution. Mexico to Paraguay.

Mexican distribution. 6 miles south of Ciudad Valles, S. L. P. (Hotel Cova-donga), June 1966-72, 47 ♂ and 23 ♀ (leg. H. A. Freeman); and Candelaria Loxicha, Oaxaca, 21 Sept. 1971, ♂, and 20 Aug. 1971, ♀ (leg. E. C. Welling).

Remarks. This species has 4 apical spots that are sub-equal. The spot in space 9 is small and the ones in spaces 8 to 6 are progressively larger forming a straight line. Rarely is there a small spot in space 1b under the spot in space 2. The spot in space 2 is quadrate and is located with its inner surface directly under the center of the cell spot. The spot in space 3 is located over the outer edge of the spot in space 2 and not touching the cell spot. There is no indication of discal spots on the upper surface of the secondaries and only slightly indicated on the lower surface. Sometimes there is a whitish spot at the lower end of the indistinct discal band in space 1c. On the lower surface of the secondaries space 1b from base to middle deeply grooved and at the distal end of the groove there is a small erect hair tuft on vein 1b. Tails fairly short in the males and long in the females. Maculation white. Head and thorax above green, intermixed with brown scales. Specimens in the Valles area are slightly less green than those from Oaxaca.

ACKNOWLEDGMENTS

I thank the National Geographic Society for grants supporting this work.

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PREDATORY BEHAVIOR IN *LITHOPHANE QUERQUERA* AND OTHER SPRING CATERpillARS

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ABSTRACT. Predatory tendencies are widespread among relatively polyphagous noctuid larvae feeding on spring foliage of forest trees but not among their more host-specific relatives. Prey capture behavior of *Lithophane querquera* is complex and highly stereotyped. Predation may be especially important during defoliator outbreaks since larvae can change from eating foliage to eating defoliators.

It is well known among lepidopterists that certain larvae will engage in cannibalism, especially under crowded laboratory conditions or if deprived of their normal food. Some noctuid species are reportedly largely predatory in nature, e.g., *Cosmia* and *Enargia* spp. (Forbes, 1954). However, little consideration has been given to the ecological significance of facultative larval predation and I am aware of no published accounts of specialized predatory behavior patterns in the Noctuidae or in other facultatively predacious Lepidoptera.

I have reared many thousands of noctuid larvae and although studying cannibalism was not a primary purpose of such rearings, some relevant observations were made and I suggest some ecological implications of these predatory tendencies.

Among the Lithophanini (Noctuidae: Cuculliinae) predatory tendencies are quite widespread in certain genera, but nearly absent in others. Species showing no predatory (i.e., cannibalistic) tendencies even in crowded, confined, laboratory conditions included: five species of *Metaxaglaea* (two presently undescribed), *Chaetaglaea sericea* (Morrison), *C. tremula* (Harvey), *Epiglaea decliva* Grote, *E. apiata* Grote, *Eucirroedia pampina* (Guenée), *Pyreferra pettiti* (Grote), *P. hesperidago* (Guenée), *P. citrombra* Franclemont, *Lithophane semiusta* (Grote), *L. patefacta* (Walker) (from Wisconsin), *L. signosa* (Walker), *Eupsilia morrisoni* (Grote) and *Homoglaea hircina* Morrison. Species showing slight to moderate predatory tendencies, at least when crowded, included: *Eupsilia sidus* (Guenée) (only when starving, larvae observed in sleeves only), *E. species near cirripalea* (late last instar only, including when sleeved), *E. vinulenta* (Grote) (late last instar only), *Xylena curvamacula* (Morrison), *Lithophane bethunei* (Grote and Robinson) (especially third and fourth instars), *L. innominata* (J. B. Smith), *L. hemina* (Grote) (seldom if ever when sleeved), *L. petulca* (Grote), *L. grotei* (Riley) (especially third and fourth instars, including sleeved larvae),

Sericaglaea signata (French) (last instar only, not when sleeved) and *Jodia rufago* Hübner (rarely, only if food was wilting). Species showing extreme predatory tendencies (i.e., it was rarely possible to rear more than one per container) were: *Lithophane baileyi* (Grote), *L. tepida atincta* (J. B. Smith), *L. querquera* (Grote) (sleeved larvae also highly predacious), and a fourth *Lithophane* species that ranges from southern New Jersey southward and has generally been included with *L. patefacta* in collections and by Forbes (1954).

All of the observations reported above were in crowded, laboratory conditions except where noted. The cuttings used as food cannot be considered optimal (Schweitzer, 1977) even though they were very seldom visibly wilted. Sleeved larvae had natural quality food but were crowded, about 25–50 per 51 × 82 cm sleeve. However, at least under stress conditions, those species indicated as predatory could be expected to eat other caterpillars in the field. Except for *Eupsilia sidus* and probably *Jodia rufago*, all of them ate other larvae even when suitable foliage was available. Furthermore, *L. bethunei* is known to be a predator on *Malacosoma* pupae in the field (Sanders and Dustan, 1919). The Eurasian *Eupsilia transversa* (Linnaeus) is also reportedly predacious in the field (Stokoe and Stovin, 1948). Sleeved larvae of all species of *Metaxaglaea*, *Chaetaglaea*, *Pyreferra* and *Homoglaea* were found to be non-predacious even after 24–48 hours of starvation.

Further information on larvae of most of the above species can be found elsewhere (Forbes, 1954; Schweitzer, 1974, 1977). Exceptions are *Lithophane signosa* which feeds only on *Platanus occidentalis* and one of the undescribed *Metaxaglaea* which accepts and grows (but not well) on a variety of woody plants (its natural host is unknown). Table 1 summarizes the feeding habits of predatory and non-predatory species.

Of the highly predatory species only *L. querquera* has been studied in detail. I have reared nine broods, all highly cannibalistic. The last instar larvae seem to prefer caterpillars but accept most deciduous tree leaves and also various rosaceous fruits and flowers. The frequency of predatory behavior, even at low densities, as well as the stereotyped behavior described below strongly indicates this species is at least substantially predacious under natural conditions.

Based on observations of 25–30 *L. querquera* (two broods), larvae exhibited the following behavior toward prey (various noctuid or decapitated *Tenebrio* larvae). When the prey approaches the larva, or is dropped near it, the larva raises its anterior portion slightly and begins waving to each side, usually rather slowly. When contact is made, the prey is grasped with the true legs and the attacker works quickly to the caudal region where the initial bite is made (Fig. 1), except in the case

TABLE 1. Larval feeding patterns of predacious and non-predacious Lithophanini. Polyphagous species are those feeding regularly on two or more plant families, facultatively polyphagous species are those appearing to have definite food preferences and restricted feeders can complete development only on a limited array of plants (see Schweitzer, 1977).

Predatory tendency	Genus	Feeding pattern			
		Polyphagous	Facultatively polyphagous	Restricted	Uncertain
None	<i>Lithophane</i>	0	2	1	
	<i>Pyreferra</i>	—	—	3	
	<i>Eupsilia</i>	1	0	—	
	<i>Homoglaea</i>	—	—	1	
	<i>Metaxaglaea</i>	1	0	3	1
	<i>Epiglaea</i>	—	1	1	
	<i>Chaetaglaea</i>	—	2	—	
	<i>Eucirroedia</i>	—	—	—	1
	total non-predacious	2	5	9	2
Slight to moderate	<i>Xylena</i>	1	0	0	
	<i>Lithophane</i>	4	1	0	
	<i>Eupsilia</i>	2	1	—	
	<i>Sericaglaea</i>	1	—	—	—
	<i>Jodia</i>	—	—	1	
Extreme	<i>Lithophane</i>	3	1?	0	
	total predacious	11	3	1	0

Note: The symbol — indicates no species in that genus exhibits the indicated feeding strategy in the eastern United States; 0 indicates that no species exhibiting a particular feeding pattern was found to fit into the predation category indicated.

of decapitated *Tenebrio* in which case feeding usually starts at the wound. Frequently the entire prey is eaten, but rather often the head capsule is discarded. Prey may vary considerably in size range and can be larger than the attacker. Occasionally *L. querquera* larvae encounter non-moving prey and bite into the caudal portion quickly, omitting the waving motions. The advantage of grasping the prey caudally may be that this prevents it from jumping or dropping away. Both *L. querquera* and *L. t. atincta* larvae have also been observed to turn and run down moving caterpillars.

Table 2 presents data from an experiment designed to determine if *L. querquera* larvae could grow well on an exclusively vegetable diet. All larvae hatched 16 May 1975 and were reared individually in 230 ml glass jars. Food was primarily foliage of *Pyrus* \times *purpurea* for the first five instars. Thereafter, half of the larvae were maintained on this diet, with fresh food daily, during the last instar. The others were also given noctuid or decapitated *Tenebrio* larvae about every second day. These prey larvae were always eaten, and were often taken within 4 or 5

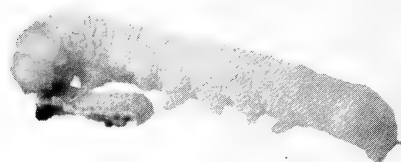


Fig. 1. Last instar larva of *Lithophane querquera* (Southford, New Haven Co., CT.) beginning to eat a third instar *Xylena curvimacula* (Sunderland, Franklin Co., MA.) (Photo by William Sacco, Peabody Museum Photography Laboratory: twice life size).

seconds. In many cases small amounts of foliage were subsequently eaten. The final body weights are very close for both groups and neither survival nor growth rates (based on maturation date) differ statistically. Thus *L. querquera* larvae are clearly not obligately predatory. It is somewhat surprising that no advantage can be shown for the predators. Perhaps the *Tenebrio* larvae which constituted over half of the prey are a poor food, or the *Pyrus* may be exceptionally suitable.

Predatory behavior probably serves to reduce the effects of competition

TABLE 2. Comparisons of body weights for sibling *L. querquera* larvae fed foliage vs. mixed foliage-insect diets during their last instar. Weights were taken the afternoon following the last night of feeding and are in grams.

Date matured	Food in last instar	
	Foliage (N = 16)	Insects and foliage (N = 17)
16 June	.2818	
17 June	.3203	
18 June		.2856
19 June	.2627	.2842
21 June	.2813	.2822
22 June	.2260	
23 June	.2727	.2614, .2377
26 June	.2119	.1952, .2801, .2480
27 June		.3363, .2331
28 June	.2802, .2556	.2610
29 June		.2631
3 July		.2338
mean weight	.2658	.2617
% survival	56.3	76.5

Comparison of survival data gives $\chi^2 = 1.58$, $p \gg .05$. Comparison of maturation dates by a Mann-Whitney U-test (Siegel, 1956; 2 tailed large sample procedure) gives $U = 39.5$, $p = .1936$.

for food from other caterpillars in certain situations. Even before the disturbance brought on by European man and the pests he has imported to North America, occasional spring canopy defoliation probably occurred in the eastern deciduous forests. Likely defoliators would include the several Geometridae commonly known as canker worms (Craighead, 1950). In fact, *Lithophane* larvae themselves occasionally cause local canopy defoliation (Craighead, 1950; Rings, 1968, 1973). A facultative predator (or cannibal) could switch from eating foliage to eating defoliators during outbreak periods. It is not known whether any lithophanine larvae will eat gypsy moth (*Lymantria dispar* [Linnaeus]) larvae, but usually defoliations caused by that species occur after most *Lithophanini* have finished feeding. It is interesting to note that one of two generalized feeders (Table 1) listed as nonpredatory, *Eupsilia morrisoni*, apparently feeds on understory plants in its late instar (Rings, 1969) and thus would be little affected by canopy defoliation.

Apparently, however, it is difficult for specialized feeding larvae to evolve (or retain) predatory behavior since nine out of ten restricted feeders (and most others with distinct preferences) are non-predatory (Table 1). In addition, I find no evidence of cannibalism among ten early feeding species of *Catocala* I have reared. Larvae of this genus are highly specialized feeders and none is reported as cannibalistic even in confinement (Sargent, 1976). Furthermore, the clear lack of cannibalism among crowded *Lithophane signosa* and less crowded *L. semiusta* and *L. patefacta* (whose very near relatives include predacious species) suggests this tendency may be lost as specialized feeding habits evolve, assuming that these species evolved from more generalized relatives. This assumption is questionable for *L. semiusta* but seems very likely for the others.

At the other extreme *L. querquera* represents a generalist that has evolved into a substantially predacious niche. In addition to the behaviors already described, it seems to differ from other *Lithophanini* by being somewhat more active, both nocturnally and diurnally. Presumably, increased locomotor activity increases the chance of encountering suitable prey.

Another interesting feature of *L. querquera* that perhaps related to its hyperactivity is its unusual coloration. This species may be warningly or mimetically colored since, unlike all other known *Lithophane* larvae, *L. querquera* larvae do not appear to be cryptic. They are greyish or bluish to whitish with a bright yellow pattern (Schweitzer, 1974, 1977). The color and pattern, however, are quite close to those of *Pyreferra ceromatica*, *hesperidago*, and *citrombra*. These three feed almost entirely on *Hamamelis virginiana* in southern New England (Schweitzer, 1977),

where they are easily found on the undersides of the leaves in May and June.¹ Possibly they derive some toxic or noxious substance from this plant and are mimicked by the less numerous, but presumably edible, *L. querquera* larvae. The possibilities of mimicry or unpalatability could be investigated experimentally if stock of these species were available.

The predatory habits of noctuid larvae have received very little attention from ecologists or entomologists. A more precise system of classifying predatory tendencies could be devised. The observations presented here suggest that predatory tendencies may be an important factor favoring non-restricted feeding habits among spring canopy feeding noctuid larvae. It seems likely that the impact of severe competition for food would be less for such larvae than for their restricted, non-predatory relatives. Experimental studies of predation during simulated cankerworm outbreaks will be reported elsewhere. In some instances cannibalism may be an important mechanism of self-regulation.

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¹ *P. citrombra* is reportedly a *Corylus* feeder (Forbes, 1954), but southern New England larvae accept only *Hamamelis* (2 spp.) and I have collected them on *H. virginiana* in Massachusetts and at Philadelphia, Pennsylvania. *P. ceromatica* has apparently not been collected in New England or neighboring regions for about 60 years, but was once fairly common there.

A HOLOTYPE DESIGNATION FOR *PAPILIO CINYRAS RIDENS* MASTERS 1971 (PAPILIONIDAE)

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ABSTRACT. In an earlier paper (Masters, 1971) the name *ridens* was elevated to subspecific rank for the first time. Although the name was attributed to Fassl, the International Code of Zoological Nomenclature provides that if an infrasub-specific name is elevated to the rank of the species group, it will take the date and authorship of its elevation. Thus *Papilio cinyras ridens* should be attributed to Masters (1971). A holotype male is designated and will be deposited in the Los Angeles County Museum of Natural History, Los Angeles. The specimen is from Buenavista, Dept. Santa Cruz, Bolivia and was collected by Franz Steinbach in 1962.

In an earlier paper (Masters, 1971), I elevated an old infrasubspecific name of Fassl (1915) to subspecific status as *Papilio cinyras ridens* attributing the name to Fassl. At the time I thought I was elevating and conserving an old name, however the provisions of the International Code of Zoological Nomenclature (Anonymous, 1964) provide (Article 10b) that "A name first established with infrasubspecific rank becomes available if the taxon in question is elevated to a rank of the species-group, and takes the date and authorship of its elevation." Thus the name *ridens* should be attributed to Masters with the authorship date of 1971. There is an obvious problem here; at the time of publication I did not realize that I was establishing a new taxon, and while identification characters and geographic criteria were given, no type specimens were established. In order to rectify this situation, I hereby establish the following types:

Papilio cinyras ridens Masters 1971

Holotype. Male, Buenavista, Dept. Santa Cruz, Bolivia, collected by Franz Steinbach (May 1962). Deposited in the Los Angeles County Museum of Natural History, Los Angeles.

Paratypes. 19 males, 3 females, same data as holotype (various dates). Presently in the author's collection but will be distributed (upon request) to any persons working on taxonomy of Neotropical Papilionidae.

Papilio cinyras ridens is well-depicted in color by Fassl (1915). My original paper (Masters, 1971) provides a sketch showing the distinguishing characters between it and other subspecies of *Papilio cinyras*; it also gives the criteria for separating *Papilio cinyras* from *Papilio thoas* (all of which were combined under *Papilio thoas* by Rothschild and Jordan, 1906). I regard *Papilio cinyras* to comprise the following:

(a) *P. c. cinyras* Menetries, Peru

- (b) *P. c. ridens* Masters, Eastern Bolivia
 (c) *P. c. brasiliensis* Rothschild & Jordan, Brazil and southward.

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MELIPOTIS INDOMITA (NOCTUIDAE) IN HAWAII AND CONNECTICUT

Recently while curating material of *Melipotis indomita* (Walker) at the Peabody Museum, Yale University, I encountered two specimens from unusual localities which seemed to merit a brief note. The data are as follows:

HAWAII: Oahu, Honolulu Co., Honolulu, 28 May 1974 *leg.* Joseph G. Gall, a fresh male.

CONNECTICUT: Litchfield Co., Washington, at home lights, 31 July 1958, *leg.* Sidney A. Hessel, a worn female.

Forbes (1954, Lepidoptera of New York and Neighboring States, Part 3, Cornell Agric. Exp. Sta. Mem. 329) gives the distribution as, "Southern states; reported northward at Kittery Point, Maine, Long Island, St. Louis, Missouri (not rare) and Delaware." Most Peabody Museum specimens are from Arizona.

The Connecticut record is remarkable since the specimen was taken in the Litchfield hills, about 47 km from the coast. It probably arrived there by natural dispersal. The species probably has been accidentally introduced to Hawaii by human transport. No species of *Melipotis* Hübner or the closely related *Drasteria* Hübner (*sensu* Forbes, 1954) is reported from the Hawaiian Islands by Zimmerman (1958, Insects of Hawaii, vol. 7, Univ. of Hawaii Press, Honolulu).

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THE TYPE LOCALITY OF *ARGYNNIS ZERENE* BOISDUVAL (NYMPHALIDAE): A CORRECTION

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ABSTRACT. *Argynnis zerene* Boisduval was described from material collected by P. J. M. Lorquin during 1850 and/or 1851 in California. The original description gives the locality as the low mountains of California. Dos Passos and Grey restricted the type locality to Yosemite Valley, Mariposa County, California. This is not possible, since Yosemite Valley was not discovered until 1851 and Lorquin could not have collected there before 1856—four years after the published description of *zerene*. The type locality is corrected and redesignated as vicinity of Agua Fria, Mariposa County, California. This taxon is now subjectively placed in the genus *Speyeria*.

Argynnis zerene (a species now subjectively placed in the genus *Speyeria*) was described by Jean Boisduval (1852) from material collected in California in 1850 and/or 1851 by P. J. M. Lorquin. In the original description, Boisduval stated simply that *zerene* occurred in the low mountains of California in June. Dos Passos and Grey (1947), without citing any reasons, restricted the type locality to Yosemite Valley, Mariposa County, California.

This is impossible. The discovery of Yosemite Valley was on 27 March 1851, by a military party under the command of Major J. D. Savage, during the Mariposa Indian War (Farquhar, 1965: 72). Yosemite was not visited again until late June 1855 when J. M. Hutchings led a party of four there. Hutchings is known to have collected butterflies for Henry Edwards at a later time (Edwards, 1878), but certainly did not collect any at this time. The Hutchings Expedition brought publicity to Yosemite and by the close of 1855, total tourist travel to Yosemite had reached 42 (Farquhar 1965: 117-118). The first structure in Yosemite was erected in 1857 with the intent to operate it as a hotel, however it was 1859 before any appreciable travel to Yosemite took place (Farquhar, 1965). If Lorquin ever collected in Yosemite, it is impossible for him to have done so before 1856 and extremely unlikely before 1859.

The exact localities where Lorquin collected in 1850 and 1851 are not known. We do know that he collected in the vicinity of San Francisco and the placer mines of Tuolumne County (cf. Grinnell, 1904). In another paper (Masters, in preparation) I have determined that it is highly probable that he spent the spring and early summer of 1851 in an area bounded by Mokelumne Hill (Calaveras Co.) on the north and Coarsegold (Madera Co.) on the south. An area which includes the mining towns of Murphys and Angel's Camp (Calaveras Co.), Sonora

and Columbia (Tuolumne Co.), and Agua Fria (Mariposa Co.). He could have been in any of these towns, or in several of them.

Of these possibilities, Agua Fria is the closest to Yosemite. As it is quite possible that Lorquin could have been in Agua Fria, I hereby designate it as the corrected type locality for *Argynnis zerene*. There is nothing left of Agua Fria now, but in 1850 and '51 it was a booming placer gold camp and the county seat of Mariposa County. The town was located on Agua Fria Creek just west of the present town of Mariposa and some 35 miles southwest of Yosemite Valley.

Dos Passos and Grey (1947) considered *Argynnis monticola* Behr (types taken in Yosemite Valley in 1863 by the California Geological Survey) a subjective synonym of *Speyeria zerene*. Considering Yosemite Valley as the type locality for *S. zerene* facilitated this conclusion. The correction of the type locality to Agua Fria should not upset the taxonomic conclusions of Dos Passos and Grey and will not change any of the synonymies per contemporary usage. Agua Fria is in the same biotic province as Yosemite Valley and it is unlikely that any future systematist would consider populations from the two localities as separate and distinct subspecies.

The type specimen of *Argynnis zerene* is in the U.S. National Museum in Washington, *ex* collection Barnes, *ex* collection Oberthur, *ex* collection Boisduval.

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NOTES ON CHILEAN OECOPHORIDAE

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ABSTRACT. The rediscovery of *Hyperskeles choreutidea* Butler is recorded and the genitalia are illustrated for the first time. *Tyriomorpha* Meyrick, 1918 (= *Mattea* Duckworth, 1966), New Synonymy, is noted. The information contained in this short paper was not available in time to be included in my recent paper (Clarke, 1978), the latter in press over two years.

Hyperskeles Butler

Hyperskeles Butler, 1883: 78 (Type-species: *Hyperskeles choreutidea* Butler loc. cit.: 79 [by monotypy].)—Fletcher, 1929: 114.—Gaede, in Bryk, 1939: 398.

The original description of this genus is as follows: "Allied to *Oecophora*, aspect of *Dasycera*; secondaries broader than in either genus; the primaries rounded at apex, but with the external angle well defined and consequently with short fringe; antennae filiform; palpi slender, porrect, long and widely separated; legs long and thick, but not fringed."

An emended generic description follows:

Labial palpus smooth, rather slender, recurved, slightly exceeding vertex; third segment nearly as long as second, acute. Tongue well developed, thickly scaled; maxillary palpus minute, slender, free. Head with closely appressed scales, small sidetufts spreading; ocellus absent. Antenna filiform; scape without pecten. Thorax smooth. Forewing smooth, costa slightly arched, termen convex, 11 veins; 1b furcate; 1c preserved at margin; 2 and 3 connate from angle of cell; 4 approximate to 3; 5 nearer to 4 than to 6; 6 to termen slightly below apex; 7 and 8 coincident to costa slightly before apex; 9 nearer to 7 + 8 than to 10; 11 from middle. Hindwing with 8 veins; 2 remote from 3; 3 and 4 stalked; 4 to 7 parallel and equidistant. Hind tibia smooth. Abdominal terga weakly setose; setae deciduous.

Male genitalia with uncus and gnathos well-developed, socius absent. Vesica armed.

Female genitalia without signum.

This genus keys to *Despina* in my key (Clarke, 1978:3) but differs from that genus by the filiform antenna, 2 and 3 connate, and the broadly rounded termen in forewing.

Hyperskeles choreutidea Butler

Figs. 1-5

Hyperskeles choreutidea Butler, 1883: 78.—Bartlett-Calvert, 1886: 346.

Hyperskeles choreutidia [sic] Gaede, in Bryk, 1939: 398.

Male genitalia slide USNM 77489 (AB June 18, 1934). Harpe triangular, cucullus bluntly pointed; sacculus sclerotized, terminating in a pointed process, the latter extending two-thirds across middle of harpe; base of harpe with lunate, setose pad on inner surface. Gnathos a slender hook. Uncus clavate; inner surface, distad, clothed with setae. Vinculum U-shaped. Tegumen about as long as uncus. Anellus



Figs. 1-5. *Hyperskeles choreutidea* Butler: 1, dorsal view of adult; 2, venation of wings; 3, ventral view of male genitalia with left harpe and aedeagus removed; 4, aedeagus; 5, ventral view of female genitalia.

an oval sclerotized plate with deep median cleft. Aedeagus slender, nearly straight, distally pointed; vesica armed with fine cornuti.

Female genitalia slide USNM 24378. Ostium transverse, crescentic. Antrum a sclerotized cone. Inception of ductus seminalis ventrolaterally slightly before antrum. Ductus bursae membranous. Bursae copulatrix membranous with a slightly rugose section posteriorly. Signum absent.

Holotype: British Museum (Natural History).

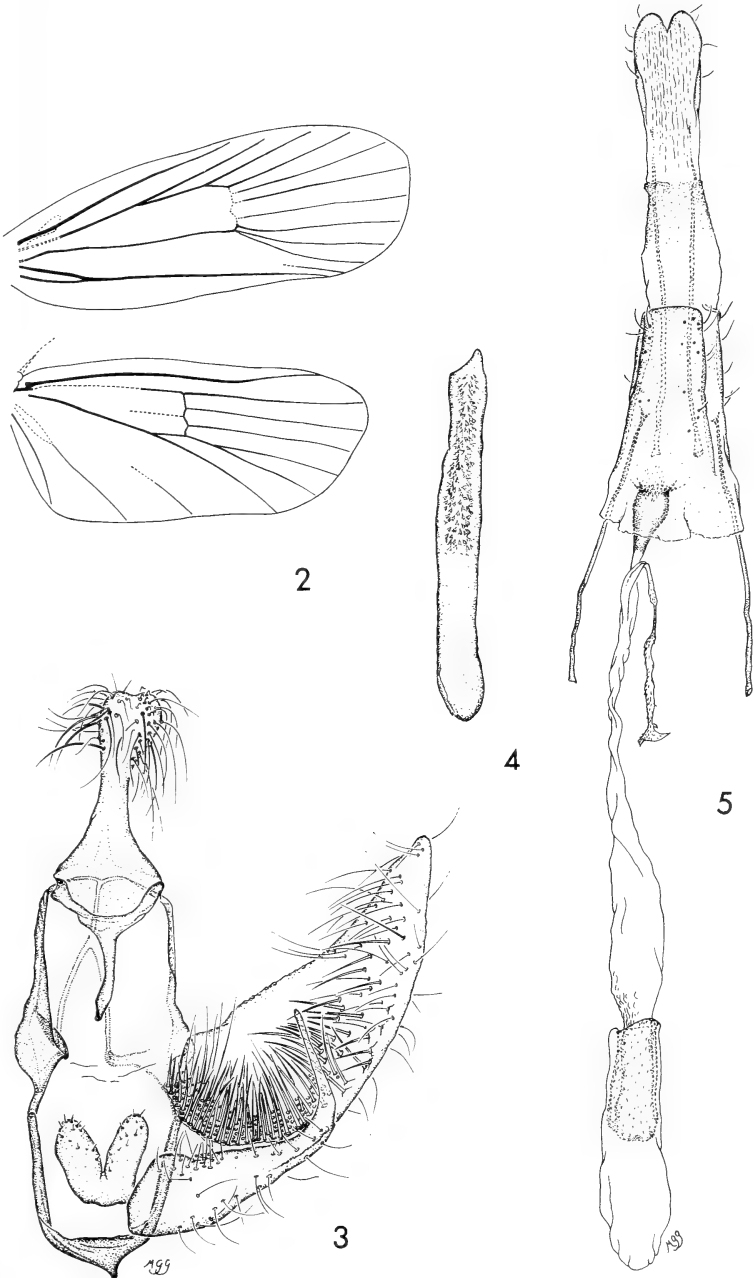
Type locality: Valdivia.

Distribution: Chile, Argentina.

The known distribution of the species, in addition to Valdivia, the type locality, is as follows: Chile, ♂, ♀, Callipulli ("a town in Chile, in the province of Malleco, 90 mi SE of Concepción"), March, Silva; S. Chile, ♂, Los Muermos, (Forest) 19 Jan. 51. R. Michelbacher; Argentina, ♀, prov. Chibut, El Tutbio. Lago Puelo, 25.III.1961, Gy Topál.

Foodplant: Unknown.

As far as I am able to ascertain, this species has been "lost" since 1886 (p. 346) when Bartlett-Calvert listed it under the Gelechiidae in his catalogue of the Lepidoptera of Chile. Gaede listed it (1939:398) under the Oecophoridae but Fletcher (1929:114) listed the genus and species as questionably oecophorid.



Figs. 1-5. Continued.

In the United States National Museum of Natural History there are two specimens (♂ & ♀) that had remained hidden in the unworked Choreutidae since the early 1930's until discovered recently by John Heppner while he was working on that family. Heppner acquired a third specimen (♀) from Dr. L. Gozmány of the Zoological Department, Hungarian Natural History Museum, Budapest, and a fourth specimen (♀) from the Los Angeles County Museum where they were thought to be choreutid. When Heppner brought the specimens to me, aware that they were not choreutids, I recognized them immediately from a colored illustration (origin unknown) in the collection of the United States National Museum of Natural History.

Through the courtesy of Dr. Klaus Sattler, British Museum (Natural History) I learned (*in litt.*) that the type ♀ of *choreutidea* is in that museum where it had been placed in the Gelechiidae.

The following synonymy was brought to my attention by Dr. John Heppner and Dr. Klaus Sattler:

Tyriomorpha Meyrick, 1918, Exotic Microlepidoptera, 2: 191 (Type-species: *Cryptolechia phoenissa* Butler, 1883, Trans. Ent. Soc. London, 81, pl. 11, figs. 12, 12a [by original designation].)

Mattea Duckworth, 1966. Proc. U.S. National Museum, 119 (No. 3540): 2 (Type-species: *Cryptolechia phoenissa* Butler, 1883, Trans. Ent. Soc. London, 81, pl. 11, figs. 12, 12a [by original designation].) New Synonymy.

Cryptolechia phoenissa Butler was originally placed in the Gelechiidae, where it remained until Duckworth (1966) placed it correctly in the Oecophoridae. When Meyrick (1918) described *Tyriomorpha* he added to the confusion by placing it in the Glyphipterygidae. Clarke (1978: 7) also placed the species correctly in the Oecophoridae, but in the genus *Mattea* Duckworth.

ACKNOWLEDGMENTS

The drawings for this paper were made by Margaret Garrison and the photograph was produced by Victor Krantz, Smithsonian Institution.

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Journal of The Lepidopterists' Society
33(2), 1979, 143-145

GENERAL NOTES

NOTES OF MARYLAND LEPIDOPTERA. 6. OCCURRENCE OF *BOLORIA SELENE* (NYMPHALIDAE) IN MARYLAND

In 1941, Clark (J. Wash. Acad. Sci. 31: 381-384) named a new subspecies of *Boloria selene* from specimens he had caught near Beltsville, Maryland in 1929. It was described as single brooded and "... resembling *Brenthis selene myrina* but larger . . . and with the ground color above darker and more reddish and the black markings broader and heavier. . . ." Clark had pictured the type earlier in his *Butterflies of the District of Columbia and Vicinity* (1932, U.S. National Mus. Bull. 157) and later (Clark and Clark 1951, Smithsonian Misc. Coll. 116, No. 7. 239 p.) reported that the 1929 specimens were the last to be found in Beltsville.

This subspecies, named *marilandica* (Fig. 1), reappeared in Largo, Maryland in 1941 when Dr. Warren Wagner, Jr. captured at least one specimen there (Clark and Clark, loc. cit.). In 1948 and 1949, one of us (WAA) caught several specimens which were first identified as *myrina*, but when they were shown to A. H. Clark himself in late 1952, he identified them as typical *marilandica* and noted that he was happy to know of another locality where they could be found.

Since then several more colonies have been located. They seem to be clustered around the Fall Line as it makes its way in a northeast-southwest direction through Maryland (Fig. 2). (The Fall Line is a line of rocky falls on the courses of the many streams and rivers that in Maryland empty into the Chesapeake Bay. It divides the low, flat Atlantic coastal plain from the gentle, rolling hills of the piedmont.) However, we know of no specimens caught later than 1966. This apparent disappearance may be due either to our not collecting at the right time in the swampy areas where the insects occur, or to their actual extinction, due to the pressures of human population extension into their areas which is occurring rapidly in the Baltimore-Washington-Philadelphia corridor.

An analysis of the capture dates of our "*marilandica*" specimens suggests there are three broods: late May to mid-June, mid-July to early August, and mid-August to late September.

The populations of the different areas in which we collected were somewhat variable. Many specimens were larger and darker than normal, agreeing with the description of "*marilandica*." However, we also found a few that agreed neither with "*marilandica*" or *myrina*, some being larger but lighter in color, others being smaller but having very thick, heavy black markings. Likewise, there were two colonies that existed close by those of "*marilandica*" in which all the specimens were small and only a few conforming to "*marilandica*" could be found. One of us (RSS) collected *myrina* earlier (2 September 1941) in Lutherville, Maryland, which is very near Stevenson (Fig. 2), and these specimens do not conform to "*marilandica*."

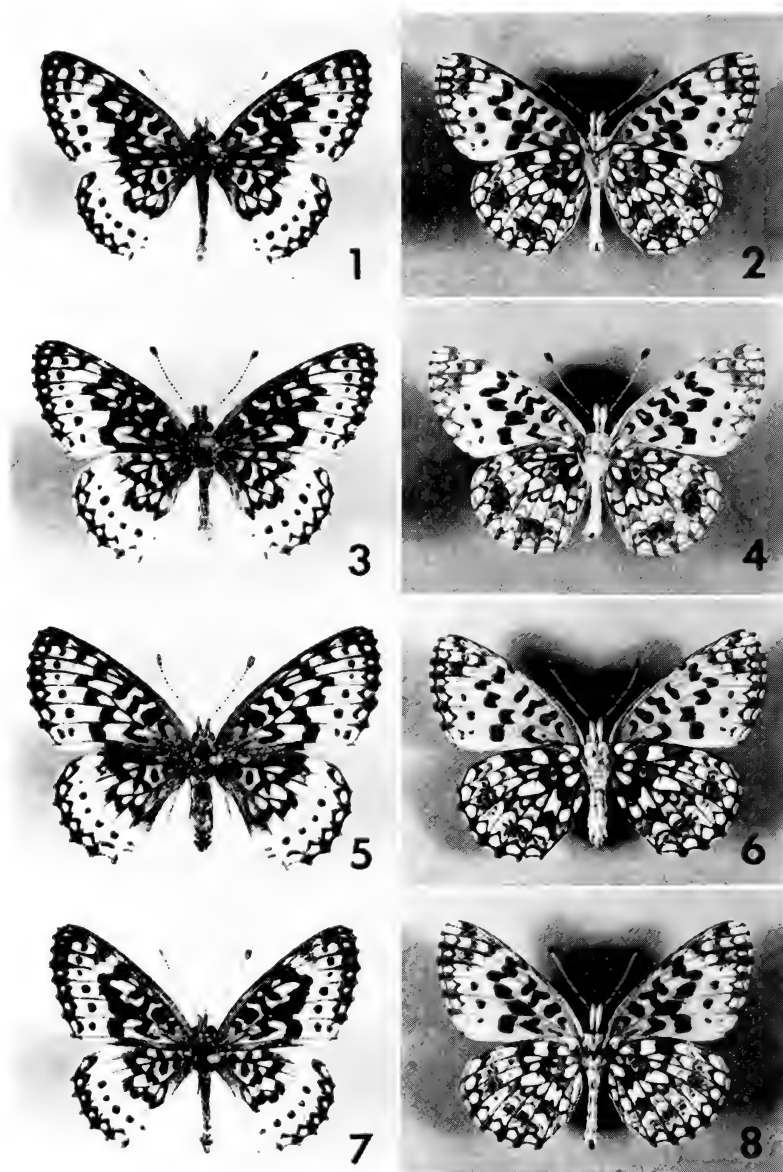


Fig. 1. *Boloria selene myrina*, form "marilandica": 1. male, Eklo, 17 July 1948; 2. same, ventral; 3. male, Eklo, 6 June 1949; 4. same, ventral; 5. female, Harkins, 2 June 1966; 6. same, ventral; 7. male, Coopstown, 14 July 1966; 8. same, ventral.

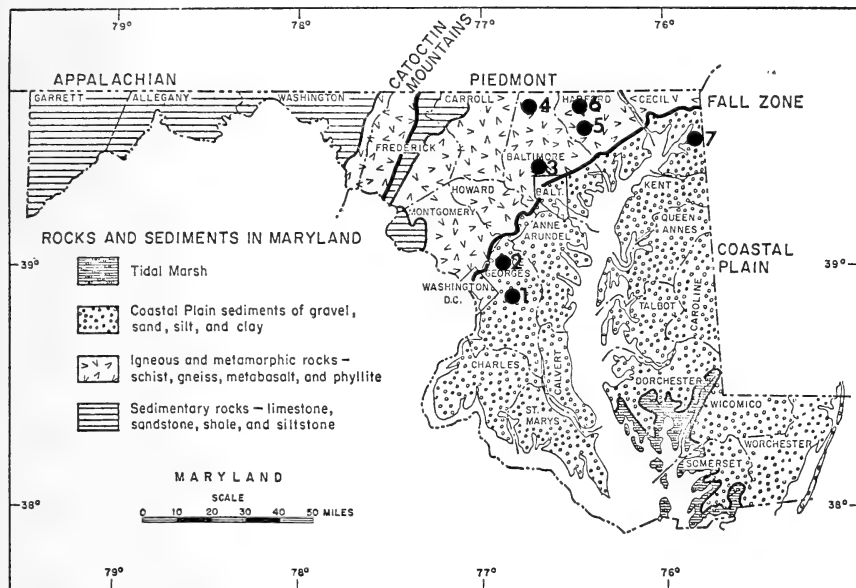


Fig. 2. Distribution of *B. s. myrina*, form "marilandica," in Maryland. Map adapted from Brush, Lenk & Smith (1977, Dept. Geography and Environmental Engineering, Johns Hopkins Univ., Baltimore, Md. 81 p.) and reproduced by written permission of the authors. 1. Largo, Prince Georges County; 2. Beltsville, Prince Georges County; 3. Stevenson, Baltimore County; 4. Eklo, Baltimore County; 5. Coopstown, Harford County; 6. Harkins, Harford County; and 7. Chesapeake City, Cecil County.

In the two small colonies in Harford County the specimens were all "marilandica." Only one specimen was obtained from the Chesapeake City (Cecil County) locale.

These observations and data support the recent revision of *selene* by Kohler (1977, J. Lepid. Soc. 31: 243-268) which places "marilandica" in synonymy with *myrina*, since "marilandica" is not single-brooded as Clark had thought, and specimens of this form are found in some populations north of Maryland (Kohler, loc. cit., Fig. 2). In fact, the type specimen of the species figured by Cramer (1779, Papillons exotique des trois parties du monde, l'Asie, l'Afrique et l'Amerique. Baalde, Amsterdam; Barthelmy Wild, Utrecht. 4 vol.), although not comparable with "marilandica" in size, appears to be just as heavily marked as "marilandica." The type specimen is from New York.

NEW MARYLAND RECORDS. **Baltimore County:** Eklo, 28 September 1947; 17 July 1948; 25 July 1948; 15 August 1948; 29 August 1948; 30 May 1949; 6 June 1949; 9 June 1949; 13 September 1962; 11 July 1963; 28 May 1964. **Stevenson,** 14 August 1965; 4 June 1966. **Lutherville,** 2 September 1941. **Cecil County:** Chesapeake City, 21 August 1952. **Harford County:** Harkins, 2 June 1966; 14 July 1966. **Coopstown,** 14 July 1966. **Prince Georges County:** Beltsville, 21 July 1961 (topotype caught by Mr. William Field and now in the collection of the U. S. National Museum, Washington, D.C.).

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Journal of The Lepidopterists' Society
33(2), 1979, 146-147

TWO SOUTHERN COSSIDS (COSSIDAE) IN THE NEW JERSEY PINE BARRENS

I have been collecting Lepidoptera in the New Jersey Pine Barrens for over ten years and have been working off and on at a regional moth list. This area is well known for harboring many unusual species, including more or less disjunct populations of both boreal and southern coastal plain species.

However, my recent discovery of two southern cossids there came as quite a surprise. The first of these, a single male of *Givira anna* (Dyar) (Fig. 1, above) was collected at a 20W black light by me at Batsto, Burlington Co. on 21 June 1969. It was identified at the American Museum of Natural History in June 1973 with the help of Dr. Alexander B. Klots and later confirmed by Dr. John G. Franclemont in August 1975. It is in my collection. Barnes and McDunnough (1911, Revision of the Cossidae of North America, Decatur, Illinois, Review Press) had records of this species only from Florida. Kimball (1965, The Lepidoptera of Florida, State of Fla., Div. of Plant Industry) gave records covering much of the state and indicated the food to be pine. I also have a male of this species from Florence, South Carolina, 14 August 1963, *leg.* V. M. Kirk. The Peabody Museum collection at Yale University contains at least three males from McClellanville, South Carolina, taken at the Wedge Plantation, 4-14 August 1967, *leg.* Charles W. Porter.

The second species is *Inguromorpha basalis* (Walker) (Fig. 1, below), a male of which was taken at Batsto on 2 July 1972 in a black light trap operated for me by Annie Carter. The specimen is in my collection. I again encountered this species at the same locality on 20 June 1977 when I took a much larger male in a MV



Fig. 1. Two southern cossids taken in the New Jersey Pine Barrens: above, *Givira anna* ♂, Batsto, Burlington Co., New Jersey, 21 June 1969, *leg.* D. F. Schweitzer; below, *Inguromorpha basalis* ♂, same locality, 2 July 1972, *leg.* A. Carter. Both specimens life-size.

Robinson trap. Unfortunately the apical regions of both forewings are badly damaged, probably from flying inside the trap. This specimen is at the Peabody Museum, Yale University.

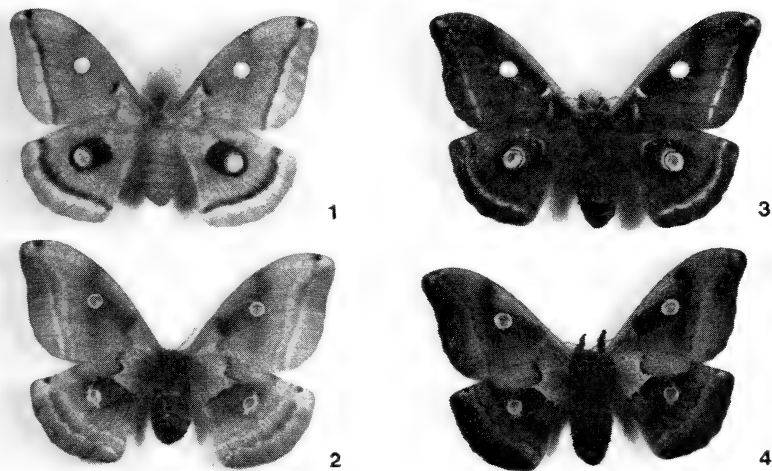
The 1972 specimen was confirmed by Dr. Franclemont along with the above *Givira*. Barnes and McDunnough (op. cit.) record it only from Florida and Kimball's records (op. cit.) cover much of that state. All of these specimens were collected within 20 m to the north of the Batsto Nature Center, situated on the top of the small hill near the east bank of the Batsto river, just above the dam. The surrounding vegetation includes a woodlot of various oaks and adventive species and extensive areas of essentially natural oak-pine and pine-oak forests extending more or less unbroken for hundreds of square kilometers, especially to the north. The pines are *Pinus echinata* Mill., and *P. rigida* Mill., with the former predominating at the immediate area of the captures.

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Journal of The Lepidopterists' Society
33(2), 1979, 147-148

A MELANISTIC SPECIMEN OF *ANTHERAEA POLYPHEMUS POLYPHEMUS* (SATURNIIDAE)

On 2 June 1975, the senior author received a living specimen of *Antheraea polyphemus polyphemus* (Cramer) that was most unusual in coloration (Figs. 1-4). The moth, a female, had eclosed on 1 June from a cocoon found approximately two weeks previously on a fence in Winnipeg, Manitoba. The cocoon had been given



Figs. 1-4. *Antheraea polyphemus* (Cramer): 1. typical female from Winnipeg, dorsum; 2. typical female, venter; 3. melanistic female, dorsum; 4. melanistic female, venter. (Photos by W. B. Preston).

to a school student, Miss Darcy Berry, who, on realizing the unusual nature of the moth, donated it to the Manitoba Museum of Man and Nature.

The general coloration is dark brown, but with the recognizable markings of *A. p. polyphemus*. The ventral surface is of the same colour as the dorsum but is contrastingly marked as is typical of specimens from Manitoba (Figs. 2, 4). In wingspan the mounted specimen measures 114 mm and the greatest length of the right front wing is 61 mm.

There are some references to melanistic *A. polyphemus* in the literature. Holland (1903, *The Moth Book*. Doubleday, New York. 479 p.) mentioned "... one or two fine melanic specimens, in which the wings are almost wholly black on the upper side." Packard (1914, *Mem. Natl. Acad. Sci.* 12: 207) referred to Holland's specimens and (p. 205) mentioned three purplish coloured specimens reared from cocoons from Macon, Georgia. Ferguson (in Dominick, R. B. et al. 1972, *The Moths of America North of Mexico*, fasc. 20.2B *Bombicoidea* (in part)) considered melanistic specimens to be very rare. The authors of the present paper are unaware of any prior published illustration of a melanistic *A. polyphemus*.

We wish to thank Mr. Richard Westwood, University of Manitoba, Winnipeg, and Mr. C. S. Quelch, Winnipeg, for examining their collections for melanistic specimens.

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Journal of The Lepidopterists' Society
33(2), 1979, 148-149

BISTON COGNATARIA (GEOMETRIDAE): FREQUENCY OF MELANIC MALES IN TYRINGHAM, MASSACHUSETTS, 1958-1977

Sargent (1974, *J. Lepid. Soc.* 28: 145-152) reported the frequency of the melanic *versus* the typical form of the Salt and Pepper Geometer, *Biston cognataria* (Guenée), in collections totalling 129 specimens (presumably all male) from central Massachusetts for the years 1971-1973. The percent of melanics ranged from zero in 1971 to 5.6 in 1973. The overall incidence for the three years was $6/129 = 4.4$ percent. Sargent discussed the question of industrial melanism and urged the continued reporting of data bearing on this problem.

During 18 years of the period from 1958 through 1977 (omitting 1961 and 1962) I examined a total of 833 males of this species taken at light in Tyringham, a rural area in southern Berkshire County of western Massachusetts, elevation 313 meters. Atmospheric pollution in the area was minimal as evidenced by the common presence of lichens on tree trunks. Collections in each year covered a period from late May to mid September or later. The overall incidence of melanism was $83/833 = 9.96$ percent. The yearly incidence ranged from zero in six of the 18 years, to a high of 33.3 percent (2/6) in 1971 (Table 1). The average of yearly incidences was 7.31 percent. Abundance of moths available for examination ranged from zero in 1970 to 253 in 1966, in which year the incidence of melanics was 11.1 percent. If any general trend is evident, it is toward a recent diminution in the number of melanics.

TABLE 1. Incidence of melanism in males of *Biston cognataria* in Tyringham, Massachusetts, 1958-1977.

Year	Melanic Form	Typical Form	Total Examined	Percent Melanic
1958	1	28	29	3.5
1959	12	93	105	11.4
1960	6	37	43	14.0
1961				(no records)
1962				(no records)
1963	1	8	9	11.1
1964	2	23	25	8.0
1965	7	69	76	9.2
1966	28	225	253	11.1
1967	17	171	188	9.4
1968	5	31	36	13.9
1969	0	3	3	0.0
1970	0	0	0	—
1971	2	4	6	33.3
1972	0	4	4	0.0
1973	0	7	7	0.0
1974	0	10	10	0.0
1975	0	10	10	0.0
1976	2	10	12	16.7
1977	0	17	17	0.0
Total	83	750	833	7.31

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Journal of The Lepidopterists' Society
33(2), 1979, 149-150

NOTES ON THE OCCURRENCE OF *ERORA LAETA* (LYCAENIDAE) IN MICHIGAN'S WESTERN UPPER PENINSULA

Erora laeta (Edwards) has been known from only one location in the upper Great Lakes region. On 14 May 1955, Edward G. Voss and Warren H. Wagner, Jr. had the good fortune of encountering four individuals of this elusive butterfly, two males and one female of which were captured. These records from Bliss Township, Emmet Co., Michigan represented a first for the state and substantially extended the known range of this exceedingly rare species. In a paper recounting these captures (Voss & Wagner 1956, *Lepid. News* 10: 18-24), the authors gave considerable attention to the environmental characteristics of the collecting site. In brief, all of the specimens were captured at or near a moist spot, which was fed by a small ground spring situated on the south side of an east-west dirt section road. Botanically, the surrounding area was described as a very young deciduous woods, with American beech (*Fagus grandifolia* Ehrh.), sugar maple (*Acer saccharum* Marsh.), basswood (*Tilia americana* L.), American elm (*Ulmus americana* L.), white ash (*Fraxinus americana* L.), and pin cherry (*Prunus pensylvanica* L.) dominating.

Beaked hazelnut (*Corylus cornuta* Marsh.) was not noted anywhere near and conifers were conspicuously absent. Subsequent collecting at this site by Voss and Wagner, along with numerous others, has failed to turn up additional specimens.

On 27 May 1975, I was collecting in an area SE of Porcupine Mountains State Park, in Ontonagon Co., principally in search of colonies of *Pieris virginiensis*. Rich northern hardwood forests along a spur service road to the Bergland Lookout Tower provided excellent collecting for several spring desirables. At approximately 1730 (CDT), a small lycaenid was noted at a mudpuddle margin along this service road, ca. 0.8 km ENE of and some 84 m below Bergland Tower (elevation 541 m). Being immediately recognized as *E. laeta*, I wasted no time in netting it. The captured specimen was an immaculate female. After a brief period of disbelief and celebration, other wet spots along the entire length of the service road were carefully checked five or six times, but no additional specimens were encountered. The entire area was again scoured on the following day, but overcast weather conditions greatly inhibited butterfly activity. Having been advised that weather conditions were not expected to change for the better, I left the area, having lost hope of finding additional individuals.

This site is approximately 400 km WNW of the Emmet Co. location where it was found in 1955, thus representing the most northwestern station for *E. laeta* known. Botanically the Ontonagon Co. site is quite dissimilar from that in Emmet Co. It can be typified as a well drained, secondary northern hardwood forest, dominated by basswood (*Tilia americana* L.), sugar and mountain maples (*A. saccharum* and *spicatum* Lam., respectively), red oak (*Quercus rubra* L.), and American elm, with occasional balsam fir (*Abies balsamea* L.), intermixed with wetter areas containing black ash (*Fraxinus nigra* Marsh.), and with trembling aspen (*Populus tremuloides* Michx.) colonies throughout. Understory shrubs include beaked hazelnut and thimbleberry (*Rubus parviflorus* Nutt.). The most conspicuous herbs during late May were the large-leaved aster (*Aster macrophyllus* L.), winter cress (*Barbarea vulgaris* R. Br.), nodding trillium (*Trillium cernuum* L.), sensitive fern (*Onoclea sensibilis* L.), and several species of violets. Many additional weedy plants occur along the disturbed roadside.

Other butterflies found associated with *E. laeta* at the Ontonagon Co. station included *Erynnis icelus* (scarce; fresh), *Amblyscirtes samoset* (common; freshly emerging), *Carterocephalus palaemon* (scarce; emerging), *Papilio glaucus canadensis* (common; fresh), *Pieris virginiensis* (common; mostly worn), *Celastrina argiolus pseudargiolus* (abundant; worn), *Nymphalis vaughani* (scarce; fresh), *Polygonia comma* (common; fresh), and *P. faunus* (common; fresh). Judging from this isolated capture, the peak flight period of *laeta* in the area appears to be fixed between the full flights of the principally early spring species (*P. virginiensis* and *C. argiolus pseudargiolus*) and those of late spring (*A. samoset* and *C. palaemon*).

Both American beech and beaked hazelnut are suspected larval hostplants of *E. laeta*. American beech is abundant at the Emmet Co. collecting site, while beaked hazelnut is very rare or altogether absent. At the Ontonagon Co. site, the opposite is true: beaked hazelnut constitutes a dominating element, while American beech was not noted at all. Warren H. Wagner, Jr., informs me (in litt.) that the westernmost extent of American beech in North America is in the north in eastern Marquette Co., eastern Iron Co., and then extending down the eastern one-fifth of Wisconsin. The nearest localities for beech are thus roughly 160 km east of the Ontonagon *E. laeta* site. Most Midwest collectors have in the past associated *E. laeta* with northern hardwood forests dominated by American beech but, in view of the present capture, it would be advisable to also concentrate collecting efforts in northern hardwood situations as characterized above.

I wish to thank Dr. Warren H. Wagner, Jr., of the University of Michigan for providing plant determinations and for reviewing the manuscript.

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Journal of The Lepidopterists' Society
33(2), 1979, 151-152

EURISTRYMON ONTARIO (LYCAENIDAE): FIRST REPORT IN MICHIGAN

On 28 June 1975, Harvey and Oosting were collecting in an area NNW of Morenci, Lenawee Co., Michigan, principally in search of *Satyrium caryaevorus*. A late afternoon stop was made at a likely-looking hairstreak location just south of Lime Creek along Munson Highway, a secondary road running north-south along the section line. An overcast sky had all but put an end to the day's field work, but a quick check was made of a roadside patch of mixed white and yellow sweet clover (*Melilotus alba* Desr. and *M. officinalis* (L.) Lam., respectively).

What appeared to be another *Satyrium* was noticed by both Harvey and Oosting taking nectar from white sweet clover. It seemed to be somewhat different from other hairstreaks taken during the day, and it was routinely swept up in Oosting's net for examination. Imagine our surprise to discover that it was a slightly worn male *ontario*, the first collection for the state of Michigan. An immediate vigorous search of the area yielded no additional specimens. The following day, accompanied by Wagner, the collectors again investigated the entire area. Sunny skies provided excellent *Satyrium* collecting, but additional specimens of *E. ontario* were not seen. Nevertheless we made a careful survey of the habitat in terms of plant species, in the hope that it might contribute something to our understanding of this elusive butterfly and its occurrence in north-central and northeastern North America.

The roadbank patch of white and yellow sweet clover, where *ontario* was captured, is bordered on the south by a large weedlot, including mainly Eurasian plants which, like the sweet clovers, have become naturalized to a greater or lesser extent as weeds. Southeast of the spot where *ontario* was collected is an extensive cornfield, like many others in an area which is made up of farms interspersed with mainly small wooded areas, these located primarily along stream valleys. Just to the south of the locality is Lime Creek, running east-west. The stream valley is rather heavily wooded, especially to the west of the locality (across the road), where there is an old pasture woods with an extensive development of hawthorns (*Crataegus* spp.) on the edges and in openings. The pastured forest (now including only a couple of cattle, but formerly more) has a tall, heavy canopy made of very common plants of sugar maple (*Acer saccharum* Marsh.), black maple (*A. nigrum* Michx.), shagbark hickory (*Carya ovata* (Mill.) K. Koch), white ash (*Fraxinus americana* L.) and basswood (*Tilia americana* L.). Less common species include red maple (*A. rubrum* L.), false shagbark (*C. ovalis* Wang.), American beech (*Fagus grandifolia* Ehrh.), hop hornbeam (*Ostrya virginiana* Mill.) and red oak (*Quercus rubra* L.). In the understorey, the clonal shrub, prickly ash (*Xanthoxylum americanum* Mill.), is common and in the low herbaceous growth are recognized such rich forest species as Virginia snakeroot (*Aristolochia serpentaria* L.), may apple (*Podophyllum peltatum* L.) and bloodroot (*Sanguinaria canadensis* L.). Lopseed (*Phryma leptostachya* L.) is especially common as an herbaceous forest-floor plant.

There is a step, darkly shaded slope on the north, running down to the stream bed and an alluvial forest, where such woody species as pawpaw (*Asimina triloba* (L.) Dunal), spicebush (*Lindera benzoin* L.), sycamore (*Platanus occidentalis* L.), and cottonwood (*Populus deltoides* Marsh.) are frequent to common. On the flood-plain forest floor are found such rich-soil plants as creeping fragile fern (*Cystopteris protrusa* (Weath.) Blasdell), blue cohosh (*Caulophyllum thalictroides* L.), liverleaf (*Hepatica acutiloba* DC) and wood nettle (*Laportea canadensis* L.). Persons familiar with southern Michigan vegetation will recognize here a plant association of luxuriant, rich woods—hardly comparable to a "shale barrens" like that described by Clench (1971, *J. Lepid. Soc.* 25: 80-82).

It is possible that the specimen of *ontario* was blown in or flew in from some distance away. Judging from its condition, however, the specimen might have originated near by. Indeed the presence of the suggested larval foodplant genus, *Quercus*, makes this not unlikely. Other species of hairstreaks, particularly *S. calanus falacer*, were common in light gaps in the woods, where they perched on shrubs and small trees. Presumably the *falacer* are attracted into open, weedy areas by the flowers present there, and they return to their natural woodland and woods-edge habitats when they are not feeding. In addition to *S. c. falacer*, the following species of butterflies were found in the general area: *Wallengrenia otho egeremet* (common), *Polites coras* (scarce), *Papilio glaucus* (common), *P. troilus* (scarce), *Satyrium caryaevorus* (common), *S. acadica* (scarce), *Chlosyne nycteis* (scarce) and *Speyeria cybele* (common).

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SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 p.

——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. *Adv. Genet.* 10: 165–216.

In the case of general notes, references should be given in the text as, Sheppard (1961, *Adv. Genet.* 10: 165–216) or (Sheppard 1961, *Sym. R. Entomol. Soc. London* 1: 23–30).

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JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



29 October 1979

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Cover illustration: Third instar larva of *Limenitis archippus* Cramer (Nymphalidae) preparing to enter winter diapause. The larva is resting on the lip of its hibernaculum constructed from the basal portion of a chewed tubular willow leaf (*Salix babylonica* Linnaeus) covered with silk. In the autumn such larvae begin facultative diapause in response to decreasing day-length. Original drawing by Mr. George C. Ford, Jr., Graphics Illustrator, Department of Biological Sciences, University of Maryland Baltimore County, 5401 Wilkens Avenue, Catonsville, Maryland 21228.

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 33

1979

Number 3

Journal of the Lepidopterists' Society
33(3), 1979, 153-161

THE MALAISE TRAP AS A MEANS OF SAMPLING BUTTERFLY POPULATIONS IN KENTUCKY¹

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ABSTRACT. Butterflies representing 57 species in 9 families were collected by means of Malaise traps at 10 localities in Kentucky during the summers of 1970-1977. The species are listed along with collecting sites, months of capture, and numbers of individuals caught. Discussion of the potential of Malaise traps for sampling butterfly populations includes an analysis of two of the three broods of *Phyciodes tharos* (Drury) at Lexington, Kentucky as sampled by Malaise traps in 1971.

One of the problems in carrying out qualitative and quantitative studies of butterfly populations in a given area is capturing specimens. Butterflies, often highly mobile and difficult to approach, have traditionally been stalked with net and killing jar—a very time-consuming procedure. Some species—those that can be attracted to rotten fruit and other non-nectar adult foods—can be collected in bait traps but this technique can be used for only a small proportion of species in most butterfly communities. The use of pheromone traps for butterflies is at best in its infancy, and would present similar limitations in breadth of appeal as the bait trap. One promising technique is the Malaise trap (Fig. 1), which collects insects by blocking their passage and taking advantage of their instinct to climb upward. This trap has already been modified by various workers for different purposes but

¹ Contribution No. 192 (New Series) of the Department of Biology, University of Louisville. This paper (78-7-170) is published with the approval of the Director of the Kentucky Agricultural Experiment Station, Lexington, Kentucky 40506.

apparently this paper is among the first to report its use in sampling butterfly populations.

Townes (1962, 1972) adapted the Malaise trap for the purpose of collecting large numbers of Hymenoptera for taxonomic purposes. Others have followed, either to assess total insect communities (Geijskes, 1968; Matthews & Matthews, 1970), or to collect particular insect groups (Breeland & Pickard, 1965, for mosquitoes; Adkins et al., 1972, for Tabanidae). Lepidoptera are usually represented as a percentage of the whole catch in general insect surveys. Percentages of each order are based on a count of all members of that order in the sample container. Thus moths and butterflies are generally lumped together, and rarely are they separated even to family level. Geijskes (1968) found in Surinam that Lepidoptera were 14.3% of catches in 1963-64, but seasonal fluctuations of 8-37% were noted. Matthews & Matthews (1970) found that Lepidoptera constituted 7.2% of their total catch during 13 weeks in 1967 at Rensselaerville, New York. Their Lepidoptera were "almost exclusively moths, the bodies of over half (49%-69%) measuring less than 3.0 mm excluding antennae."

One comprehensive study of butterfly populations collected by Malaise trap was that of Owen (1971), who used this technique in Kampala, Uganda, in 1965, and at Freetown, Sierra Leone, in 1968. He showed monthly fluctuations in numbers of individuals collected, grouping his catch by family. His only tabulation at the species level was *Acraea bonasia* (Fabr.). That common butterfly was present all year, but showed a definite peak in February and March (Owen, 1971: 70). While Malaise trap samples played only a small part in his overall study, Owen was possibly the first to demonstrate the value of Malaise traps in sampling butterflies. More recently Walker (1978) has demonstrated its value as a technique for studying butterfly migration.

METHODS

In 1970 the junior author, a leafhopper specialist, began a program of Malaise trap sampling at several localities in Kentucky: Lexington (Fayette Co.); Glendale (Hardin Co.); Bardstown (Nelson Co.); Robinson Forest (Breathitt Co.); Princeton (Caldwell Co.); Paris (Bourbon Co.); Spears (Jessamine Co.); and rural areas in Pulaski and Wayne counties. The junior author separated the Lepidoptera from other orders and the senior author subsequently identified them for the Kentucky Lepidoptera Survey. Although the Lepidoptera collected were mainly moths, a large number of small and medium-sized butterflies appeared in the samples. This material was augmented by specimens collected by University of Louisville graduate students under the supervision of the senior author in Bernheim Forest (Bullitt Co.).



FIG. 1. Malaise trap at Bernheim Forest, Bullitt County, Kentucky, 1977. The trap was 6 ft long, 4 ft wide, and 6 ft 8 in high at one end. At the high point, a hole of $2\frac{1}{4}$ in diameter led into a plastic jar, to which a plastic cyanide jar could be screwed by means of lids glued back to back and drilled with a similarly large opening to let the insects through.

Two variations of the Malaise trap were employed to obtain the results reported here. The traps used by the junior author at all sites except Bernheim Forest were Model 300.5 from Survival Security Corporation, Lake City, Minnesota 55041 (not illustrated). About 7 ft high, these traps consisted of dark nylon netting in four panels rising to a central peak supported by an aluminum pole. The top of the trap had an inverted plastic cone to direct the insects into a smaller cone placed snugly beneath the first, then narrowing downward into a cyanide killing jar. These components were supported by the center pole. Entrance space between the two cones was provided by cuts about $\frac{1}{4}$ inch deep around the top of the inner cone. The traps were selective for small insects, especially leafhoppers, so few large butterflies were included in the samples.

The trap used at Bernheim Forest (Fig. 1) was built by University of Louisville graduate student Larry Canterbury according to the directions of Townes (1972). The openings into the killing jar were larger in this trap, and several of the large butterfly species listed in Table 2 were taken only at the Bernheim Forest site. The Bernheim trap was encircled by barbed wire to discourage tampering.

TABLE 1. Numbers of total butterfly species of each family collected by Malaise trap in Kentucky, 1970-1977. Percentages of the total are indicated in the right-hand column.

Family	Number of species		Percentage
	Kentucky total	Malaise traps	
Hesperiidae	44	21	48
Papilionidae	8	3	37.5
Pieridae	13	6	46.2
Riodinidae	2	0	0
Lycaenidae	25	9	36
Libytheidae	1	1	100
Nymphalidae	29	13	45
Danaidae	1	1	100
Satyridae	8	3	37.5
Total butterfly species	131	57	43.5

RESULTS

The butterflies collected in Malaise traps were identified by the senior author and named according to the current checklist for North American butterflies (Dos Passos, 1964) and later modifications such as Howe (1975). Covell (1974) listed 123 butterfly species from Kentucky, and since then 8 more have been added. As of this writing, 57 of the 131 species, or 43.5%, have been collected in Malaise traps. No additions to the state list have resulted yet from these samples, but substantial numbers of new county records and some additional seasonal information has been recorded.

Table 1 indicates the Malaise-trapped butterfly species in each family compared with the total number known from Kentucky in that family. Species that have not been collected include (1) 5 species that are clearly "strays" and known from single Kentucky records; (2) 23 species that are either very rare, or which are found in very restricted, specialized habitats not yet sampled by Malaise trap; or (3) some of the very large butterflies which were not caught despite the Bernheim trap with large opening. It may also be that flight and walking habits of some species, not yet appreciated, may account for their absence from samples. Only one family occurring in Kentucky, the Riodinidae, has not been taken by Malaise trap; and these fly for short periods in very specialized habitats.

Table 2 lists all the butterfly species collected by Malaise trap in Kentucky from 1970 through 1977. Although the number of specimens collected by this technique over the eight-year period is only 1,883, one must remember that except at Bernheim Forest the traps were not designed or placed for butterfly collecting. The majority of spec-

TABLE 2. List of species of butterflies in each family collected by Malaise trap in Kentucky, 1970-1977. To the right of each species name are numbers representing localities from which each was collected (1-10), the months of capture (1-12), and the total number of specimens taken. Localities by number are as follows: 1, Bernheim Forest, Bullitt Co.; 2, Lexington, Fayette Co.; 3, Glendale, Hardin Co.; 4, Spears, Jessamine Co.; 5, rural Mercer Co.; 6, Robinson Forest, Breathitt Co.; 7, Princeton, Caldwell Co.; 8, Bardstown, Nelson Co.; 9, rural Wayne Co.; and 10, Paris, Bourbon Co.

Species	Localities	Months	Specimens
HESPERIIDAE			
<i>Amblyscirtes hegon</i> (Scudder)	1	5	2
<i>Euphyes vestris metacomet</i> (Harris)	2	5-9	42
<i>Poanes zabulon</i> (Bdv. & LeConte)	1,2,6,10	5-9	8
<i>Poanes hobomok</i> (Harris)	1	5-6	3
<i>Atrytone delaware</i> (Edwards)	2	6-9	8
<i>Atalopedes campestris</i> (Bdv.)	2,4,5,8,10	7-10	87
<i>Pompeius verna</i> (Edw.)	2	6,8-9	9
<i>Wallengrenia egeremet</i> (Scudder)	2,4,8,10	6-9	41
<i>Polites coras</i> (Cramer)	1-4,8	5-10	102
<i>Polites themistocles</i> (Latreille)	1-6,8	5-9	169
<i>Polites origenes</i> (Fabr.)	1,2,6,8	6,8	8
<i>Thymelicus lineola</i> (Ochs.)	2,4	5,6	68
<i>Ancyloxypha numitor</i> (Fabr.)	2-5,10	6-9	13
<i>Nastra lherminier</i> (Latreille)	4,5,7	7-8	6
<i>Pholisora catullus</i> (Fabr.)	2-5,8	5-9	214
<i>Pyrgus communis</i> (Grote)	2,3,8	7-10	15
<i>Erynnis icelus</i> (Scudder & Burg.)	2,5	4-8	50
<i>Erynnis brizo</i> (Bdv. & LeConte)	1	3-4	31
<i>Erynnis horatius</i> (Scudder & Burg.)	6	7	1
<i>Erynnis juvenalis</i> (Fabr.)	1	3-4	26
<i>Epargyreus clarus</i> (Cramer)	1,2,5,6,8	4,6-8	18
PAPILIONIDAE			
<i>Battus philenor</i> (Linn.)	1	4	1
<i>Papilio troilus</i> Linn.	1	4,6	5
<i>Graphium marcellus</i> (Cramer)	1	4,6	3
PIERIDAE			
<i>Pieris rapae</i> (Linn.)	2-5,8	5-9	139
<i>Colias eurytheme</i> Bdv.	1-5,10	5-8,10	29
<i>Colias philodice</i> Godart	1-5	4,6-10	36
<i>Eurema lisa</i> Bdv. & LeConte	3	7	1
<i>Eurema nicippe</i> (Cramer)	3,7	7-8	2
<i>Anthocharis midea</i> Hübn.	1	3-4	4
LYCAENIDAE			
<i>Harkenclenus titus mopsus</i> (Hübn.)	2	6	1
<i>Satyrrium calanus falacer</i> (Godart)	4,5	6,7	2
<i>Calycopis cecrops</i> (Fabr.)	6	5	1
<i>Callophrys henrici</i> (Grote & Rob.)	1	3-4	5
<i>Strymon melinus</i> Hübn.	1-3,5,8	4-9	21
<i>Lycaena hyllas</i> (Cramer)	3	7	1
<i>Lycaena phlaeas americana</i> Harris	2-4	6-9	19
<i>Everes comyntas</i> (Godart)	1-5,8	4-9	84

TABLE 2. Continued.

Species	Localities	Months	Specimens
<i>Celastrina argiolus pseud-argiolus</i> (Bdv. & LeConte)	1	4	6
LIBYTHEIDAE			
<i>Libythea bachmanii</i> (Kirtland)	2,3,7,8	6-8	8
NYMPHALIDAE			
<i>Asterocampa celtis</i> (Bdv. & LeConte)	1-4,7,10	6-9	58
<i>Asterocampa clyton</i> (Bdv. & LeConte)	2,3,7,8,10	8-9	8
<i>Limenitis arthemis astyanax</i> (Fabr.)	3	7	1
<i>Vanessa atalanta</i> (Linn.)	2	5,6	5
<i>Vanessa virginiensis</i> (Drury)	2	5,6	1
<i>Precis coenia</i> (Hübner)	3,8,9	6-9	4
<i>Polygonia interrogationis</i> (Fabr.)	1,2	5,6,8	6
<i>Polygonia comma</i> (Harris)	1	4	1
<i>Chlosyne nycteis</i> (Doubleday)	1,3,4	5-9	10
<i>Phyciodes tharos</i> (Drury)	1-3,5,6,8	4-10	379
<i>Boloria bellona</i> (Fabr.)	2	6-9	69
<i>Speyeria cybele</i> (Fabr.)	1,2	6-7	7
<i>Euptoieta claudia</i> (Cramer)	2,3	6-9	7
DANAIDAE			
<i>Danaus plexippus</i> (Linn.)	3	8	1
SATYRIDAE			
<i>Cyllopsis gemma</i> (Hübner)	6	6-9	4
<i>Euptychia hermes sosybius</i> (Fabr.)	6	6-9	15
<i>Megisto cymela</i> (Cramer)	1,6	5-7	18
			Total: 1,883

imens were small species, the common *Phyciodes tharos* (Drury) constituting 20% of the total. Its wingspan is approximately 3 cm. Also, the traps were placed in open fields and meadows with two exceptions: the Robinson Forest and Bernheim Forest sites. The few Satyridae collected can be attributed largely to that factor, since most of the Kentucky members of this family are woodland species. Furthermore, although some early spring collecting was done, the period from mid-March to the end of April was largely neglected; and several early spring butterflies were not collected—especially those restricted to woodland habitats. While only months of capture are indicated here, further study of the data would reveal trends in abundance of given species at a particular locality during a given year. These data might be valuable in understanding population dynamics, especially when correlated with climatic factors such as temperature and rainfall. An example of a more precise analysis is given in Fig. 2 for *Phyciodes tharos*, which has three broods in Kentucky. At Lexington in 1971, 88

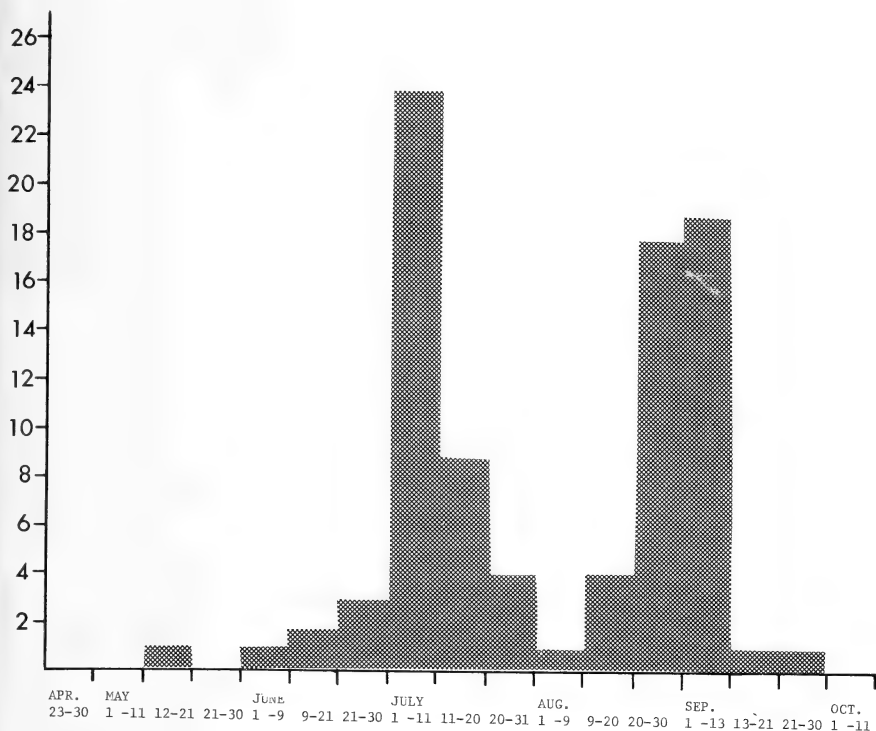


FIG. 2. Temporal distribution of *Phyciodes tharos* (Drury) collected in a Malaise trap in a Lexington, Kentucky, meadow, 23 May–11 Oct. 1971.

individuals were collected during the 17 time increments indicated on the graph. From prior experience we expect the three broods to occur in spring, midsummer, and late summer to fall. We are not certain if the single capture of 12–21 May represents the spring or midsummer brood. The spring brood was not properly sampled since that trap was not set up until about 20 April. The midsummer peak at that site in 1971 was apparently during 1–11 July, with 24 individuals collected. The next peak during the last 10 days of August and the first 13 of September was also substantial. If the trap had been checked daily instead of at rather irregular intervals, a more sensitive picture of the dynamics of *P. tharos* could have been obtained. Similar data from several years would be interesting, to give comparisons of both abundance and peak flight times for adult *P. tharos*. The Malaise technique can be used to remove individuals permanently from the population by use of a killing jar; or individuals can be marked, released, and recaptured on succeeding days for studies of that nature.

Since Fig. 2 was constructed in hindsight from butterflies collected by the junior author in 1971, one should not assume that it is intended to give anything more than a rough picture of *P. tharos* dynamics at the Lexington site that summer.

CONCLUSIONS

Large numbers of insects, including such fast fliers as moths and butterflies, can be collected with relatively little effort by using Malaise traps. By experimentation with the basic design of the trap one can enhance the efficiency of capture of either butterflies in general, or certain desired species. Some of the variables which still need attention include netting color, texture, and durability; trap size and shape; placement of collecting container, size and shape of opening into container; dimensions of container itself. Position of the trap in suitable habitat is also essential to maximize collection. Placement in a butterfly fly-way through a forest is an example of proper choice in this respect. Addition of bait may increase captures of certain desired species. If killed specimens in excellent condition are required, one must seek a long-lasting killing agent of strength sufficient to prevent damage by beetles and large insects (including Lepidoptera) that get into the container. A large live-catch cage could also be used, especially if one does not wish to make a general survey or kill everything that enters the trap. By using such a cage one can free insects that one is not interested in keeping, and thus avoid needless killing of large numbers of other insects. The more frequently the trap is emptied, the better one can expect specimen condition to be. In the collections studied in this survey, however, the condition of butterflies was remarkably good; a large proportion was nearly perfect and good enough to put in a collection. A major drawback to using killed specimens from Malaise traps seems to be the unpreventable problem of wings folding down beneath the body as the insect dies. Such specimens often have drooping wings, even after a good job of relaxing and spreading. Experimentation with other killing agents may alleviate this problem.

In addition, some other negative aspects of Malaise trap collecting in general include:

- (1) *Expense*: Unless one makes the trap himself, commercially available models run from \$100 to more than \$300.
- (2) *Weather*: Rain may ruin samples; wind can knock down the trap or bring tree limbs down on it; and sun, rain, and wind can cause deterioration of some netting materials, e.g., nylon. Dacron is more durable according to Townes (1972).

- (3) *Vandalism*: Despite signs and even barbed wire fencing (Fig. 1), traps are often prey to vandals in isolated localities. We know of cases in which traps have been destroyed or stolen on seemingly protected property.
- (4) *Lack of selectivity*: As mentioned above, one is likely to kill large numbers of insects indiscriminately by this technique unless a live-catch container is used and the trap is emptied daily.

Despite these shortcomings, however, Malaise traps show great promise for a wide variety of insect population studies, and are increasingly used throughout the world. This survey has added much information to the current study on butterflies of Kentucky; the moth material, when identified, should provide numerous important records for that aspect of the survey.

ACKNOWLEDGMENTS

The authors wish to thank their student assistants and colleagues for help in operating the Malaise traps in the various localities, and for sorting the samples: D. P. Beiter, A. J. Brownell, L. E. Canterbury, W. B. Early III, G. F. Florence, C. H. Kaster, J. S. Lesshaft, Jr., J. Pohlman, H. G. Raney, S. Reigler, and C. K. Sperka. We are also grateful to the Isaac Bernheim Foundation, Louisville, Kentucky, for the funding to carry out the survey of Bernheim Forest.

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DIFFERENTIAL GROWTH AMONG LARVAE OF *CITHERONIA* *REGALIS* (SATURNIIDAE) ON THREE GENERA OF FOODPLANTS

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ABSTRACT. Larvae of *Citheronia regalis* reared under similar outdoor conditions grow both larger and more rapidly on persimmon than on either sweetgum or sumac. We suggest that the relationship of *C. regalis* to persimmon is one of long standing, originally established in the Neotropics, whereas both sweetgum and sumac may have been exploited secondarily, as the moth entered temperate regions in more recent times.

Many species of Lepidoptera are polyphagous in the larval stage. For these larvae there often exists a spectrum of foodplant suitability, including "preferred" and "acceptable" types of host plants. Such preferences have a biochemical basis through which larvae respond to chemosensory cues. During the course of evolution, the longer an herbivorous insect and a particular plant species have been associated, the more compatible the two are likely to have become, both biochemically and nutritionally, as each species influences the evolution of the other (Brower & Brower, 1964; Ehrlich & Raven, 1965).

Larvae of *Citheronia regalis* Fabricius feed on a wide variety of deciduous trees and shrubs, including as preferred foodplants: black walnut (*Juglans nigra* Linnaeus), butternut (*J. cinerea* L.), hickories and pecan (*Carya* spp.), persimmon (*Diospyros virginiana* L.), sweetgum (*Liquidambar styraciflua* L.), as well as mountain, smooth, stag-horn, and wing-rib sumac (*Rhus* spp.). Alternate foodplants include ashes (*Fraxinus* spp.), blackgum (*Nyssa sylvatica* Marsh), oak (*Quercus* spp.), sycamore (*Platanus occidentalis* L.), willow (*Salix* spp.), lilac (*Syringa vulgaris*), and even cotton and sea-island cotton (*Gossypium* spp.), according to Holland (1903), Villiard (1969), and Ferguson (1971). This paper reports differential growth and development times of *C. regalis* reared on persimmon, sweetgum, and wing-rib sumac (*Rhus capallina* L.). Furthermore, we will suggest possible reasons why *C. regalis* larvae exhibit differential growth rates on these three foodplant genera.

MATERIALS AND METHODS

Rearing was done out-of-doors on a farm in Eldora (Cape May Co.), New Jersey by C.B.W. during the summer of 1977. Equal numbers of

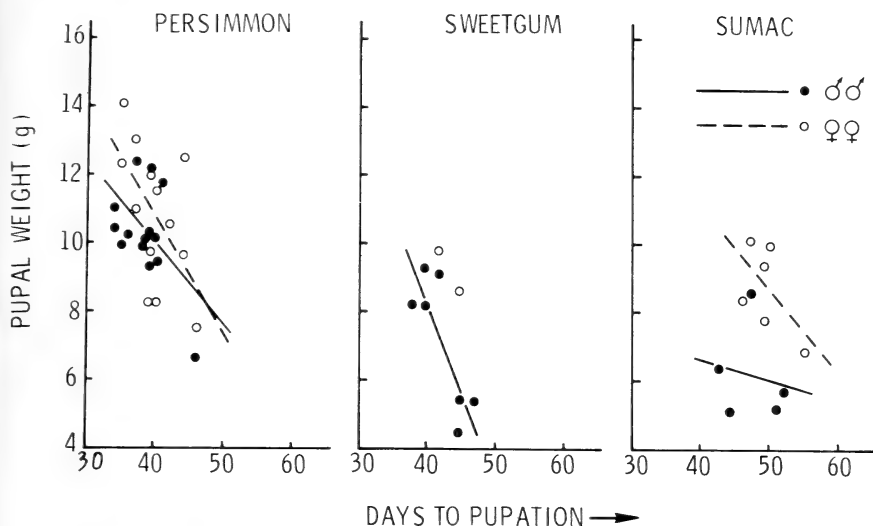


FIG. 1. Linear regression of pupal weight vs. larval development time for *Citheronia regalis* on three foodplants. Solid circles are data for males; open circles denote females. The overall slope is -0.28 ($P < 0.001$). Slopes of individual lines (except Sweetgum ♀♀ and Sumac ♂♂) also are significant ($P < 0.001$).

eggs from two females were placed in fine-mesh cloth nets on branches of the three host plants. Locations facing the same direction and having the same temporal exposure to sunlight were chosen. Larvae were reared communally until third instar, at which time they were

TABLE 1. Effects of foodplant and sex on pupal weights (g) of *Citheronia regalis* larvae, with 2-way ANOVA Test and mean pair comparisons. (Sample sizes are given in brackets.)

		FOODPLANT		
		Persimmon (PR)	Sweetgum (SG)	Sumac (SM)
Pupal weight ($\bar{x} \pm S.E.$)	♂♂	10.4 ± 0.38 [14]	7.2 ± 0.77 [7]	6.3 ± 0.64 [5]
	♀♀	10.9 ± 0.57 [13]	9.3 ± 0.60 [2]	8.9 ± 0.53 [6]

ANOVA of pupal weights¹
(food plant and sex are fixed):

Source of variation	df	Mean Square	F-statistic	P
Between foodplants	2	45.2	15.9	<0.005
Between sexes	1	16.9	5.8	<0.01
Interaction	2	4.8	1.6	>0.10 (NS)
Within subclasses	41	2.9	—	—

¹ If the means (\bar{x}) are ordered from largest to smallest, Duncan's multiple range tests show that the following means do not differ significantly from each other ($P > 0.05$): PR♀♀, PR♂♂, SG♀♀ do not differ significantly; PR♂♂, SG♀♀, SM♀♀, SG♂♂ do not differ significantly; SG♂♂ and SM♂♂ do not differ significantly.

TABLE 2. Effects of foodplant and sex on development time (days) of *Citheronia regalis* larvae with 2-way ANOVA test and mean pair comparisons. (Sample sizes are given in brackets).

		FOODPLANT		
		Persimmon (PR)	Sweetgum (SG)	Sumac (SM)
Development time	♀ ♀	38.3 ± 0.83 [14]	42.4 ± 1.25 [7]	48.2 ± 1.93 [5]
($\bar{x} \pm \text{S.E.}$)	♂ ♂	39.8 ± 0.96 [13]	43.5 ± 1.50 [2]	50.3 ± 1.28 [6]

ANOVA of development times (foodplant and sex are fixed):				
Source of variation	df	Mean Squares	F-statistic	P
Between foodplants	2	415.6	36.7	<0.005
Between sexes	1	27.6	2.4	≈0.10 (NS)
Interaction	2	0.5	0.04	>0.25 (NS)
Within subclasses	41	11.3	—	—

Duncan's Multiple range tests show that the means (sexes combined) differ significantly from each other: PR < SG < SM (P < 0.05).

reared singly or in pairs, depending on their size. Further rearing was done inside heavy cloth bags (pillow cases) covering terminal branches. During the fifth instar all larvae were inspected daily to determine the date each ceased feeding, and when each began to crawl around inside its cloth bag. Larvae were then brought indoors and were allowed to pupate in individual plastic boxes. The sex and pupal weight of each were determined on the day after the larval-pupal ecdysis.

RESULTS

Although initially equal numbers of eggs were placed on the three foodplants, the number of larvae which actually began to feed after hatching on each plant type was not recorded. When the larvae were transferred at third instar, there were 31 feeding on persimmon, 10 on sweetgum, and 13 on sumac. Thus, following the third instar, the *C. regalis* larvae exhibited approximately equal survival rates through pupation; these rates ranged from 85% on sumac to 90% on sweetgum, with 87% survival on persimmon.

Our data have been analyzed using two-way analysis of variance, with foodplant and sex fixed. In Table 1 the effects of foodplant and sex on pupal weight both are significant, but the interaction term is not. The Duncan's Multiple Range Tests on data in Table 1 indicate which of the group means differ significantly from one another. Table 2 shows that only foodplant affects development time, with neither sex nor the interaction term being significant. Fig. 1 presents a linear regression analysis of pupal weight vs. larval development time on each of the three foodplants. An inverse relation-

ship between pupal weight and development time is shown by these graphs. Clearly, the *C. regalis* larvae grew more rapidly on persimmon than on either sweetgum or sumac. Larval growth was retarded 4–5 days on sweetgum, and 10–11 days on sumac, as compared to persimmon.

DISCUSSION AND CONCLUSIONS

These results suggest that persimmon may be a more favorable foodplant for *C. regalis* in the northeastern United States than are either sweetgum or sumac. Larvae fed on the two latter plants not only exhibited a smaller final size, but they also required a longer feeding period. Yet *C. regalis* is known to oviposit on all three host plants in Eldora, New Jersey, and its larvae often have been found feeding in the wild on them. The local population probably exploits numerous other deciduous hostplants as well; both black walnut and mockernut hickory (*Carya tomentosa* Nuttall) are common species on the wooded areas nearby.

The geographic distribution of *C. regalis* closely matches the range of persimmon, whereas its other foodplants (except for sweetgum) have less extensive (mainly temperate) ranges (Fowells, 1965). We may now ask what reasons account for persimmon's optimal qualities as a foodplant for *C. regalis*? Possibly, this represents a relationship of long standing, whereas the contact between *C. regalis* and both sweetgum and sumac may have occurred more recently.

Citheronia has its generic focus in Central and South America, and persimmon, likewise, is a member of a predominantly tropical family, the ebonies (Ebenaceae). All of the other preferred foodplants of *C. regalis* are members of principally temperate zone families, either the Juglandaceae (walnuts and hickories), the Hamamelidaceae (sweetgum), or the Anacardiaceae (sumacs). These foodplants also are shared by *Actias luna* Linnaeus, another temperate member of predominantly Asiatic and tropical saturniid groups. Furthermore, the closest taxonomic relatives of *C. regalis* common in temperate regions (*C. sepulcralis* Grote and Robinson and *Eacles imperialis* Drury) are both pine feeders and have exploited very different plant species.

Although our data are by no means sufficient to prove our hypothesis we suspect that *C. regalis* and persimmon may have established their relationship long ago in the tropics, and that the two only recently invaded the North American temperate zone as biological consorts. The spread of *C. regalis* to mainly temperate plants such as sweetgum and sumac, then, may represent more recent relationships which are still evolving. Further comparative foodplant studies of *C.*

regalis and its other host plant species are warranted to test this hypothesis.

ACKNOWLEDGMENTS

We wish to thank Mr. T. Ford of the Department of Biological Sciences, U.M.B.C. for technical assistance. We also are indebted to Dr. R. S. Peigler of the Department of Entomology, Texas A&M University, for comments relating to these ideas.

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Journal of the Lepidopterists' Society
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DOUBLY OVERWINTERING *CITHERONIA REGALIS* FABRICIUS (LEPIDOPTERA: SATURNIIDAE)

In 1975 I reared 94 larvae of *Citheronia regalis* Fabricius which overwintered successfully. Among these were 50 males and 44 females. In 1976, many eclosed, but 18 males and 5 females remained dormant. This represents 36% of the males and 10% of the females, or 24.5% of the total sample.

Later, in 1977 I secured two matings between doubly overwintered moths. From ova of those females, I reared 41 larvae, the pupae of which were still viable in the spring of 1978. I could now observe whether or not the tendency of these pupae to remain in diapause over their first summer had been reinforced by the selective matings of their doubly-overwintered parents.

The pupae consisted of 20 males and 21 females. Five of these died before emergence. Among these, two males and one female developed but failed to eclose, while one male and one female showed no signs of metamorphosis. The five dead pupae were excluded from the data.

Of the remaining 17 males, 15 emerged in 1978, with only two (11.8%) remaining in diapause. Of the 19 females, 16 emerged, and only three (15.8%) remained in diapause. Thus of the total population 13.9% remained in diapause.

These observations do not support the hypothesis that double overwintering is under simple genetic control. I could not discern any other determining conditions for the phenomenon, though double overwintering must obviously have survival value for the species by carrying it through occasional catastrophic years.

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A DOCUMENTATION OF BIENNIALISM IN *BOLORIA POLARIS* (NYMPHALIDAE)¹

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ABSTRACT. Capture/noncapture records of *Boloria polaris* at Churchill, Manitoba over a 46-year timespan provide documentation that the species (at least at Churchill) is biennial, where adults fly only in odd-numbered years.

Biennialism in insects is that situation where an insect's life-cycle takes two years to complete so that imagoes are produced only after two years of pre-imaginal development. It may be accompanied by biennial flights when, in a given locality, adults fly only in alternate years (periodical flight); or it may be accompanied by annual flights. Unless biennial flights are involved, biennialism is extremely difficult to perceive in nature without carefully working out the insect's life history. Annual flights may occur when the species is only partially biennial or when two allochronic populations are involved. Documented cases of regular biennialism are very rare in Lepidoptera and heretofore have been confined to two species of moth (*Lasiocampa quercus callunae* in Europe and *Coloradia pandora lindseyi* Barnes and Benjamin in North America) and a few species of Satyridae (e.g., *Oeneis macounii* Edwards, *Oeneis nevadensis* Felder and Felder, *Oeneis jutta* Hubner, *Erebia claudina* Borkhausen, and *Erebia ligea* Linnaeus). For a review of periodical flight behavior in other insects, see Bulmer (1977).

In working on a study of butterflies occurring at Churchill, Manitoba (Masters, 1971), it became evident to me that *Boloria polaris stellata* (Masters) is biennial at Churchill and since that time, I have accumulated enough data to document this fact rather well. This is the first documentation of periodical biennialism in Nymphalid butterflies. It has been suggested, and recent collecting data tends to support the contention, that several other species of *Boloria* (e.g., *B. distincta* Gibson and *B. chariclea* Schneider) and the arctic populations of one species of Hesperiidae (*Hesperia manitoba borealis* Lindsey) will also turn out to be biennial.

Churchill, Manitoba, since the opening of the Hudson Bay Railroad in 1930, has been a classic arctic collecting locality. Because Churchill has been collected repeatedly for a span of 46 years, it is possible to document the capture and noncapture data for *Boloria polaris* from

¹ Originally submitted and accepted for publication in 1971; publication delayed due to manuscript loss in the mail. Revised to incorporate new data.

TABLE 1. Capture/noncapture records of *Boloria polaris* at Churchill, Manitoba.

Expeditions recording <i>Boloria polaris</i>	Expeditions failing to record <i>Boloria polaris</i>
1933 (A. V. Harper)	1932 (A. V. Harper)
1937 (G. S. Brooks)	1936 (H. E. McClure)
1939 (G. S. Brooks)	
1939 (B. Wilk)	1940 (G. S. Brooks)
1941 (G. S. Brooks)	1942 (G. S. Brooks)
1943 (G. S. Brooks)	1944 (G. S. Brooks)
	1946 (G. S. Brooks)
1947 (T. H. Freeman)	
1951 (A. B. Klots & R. D. Bird)	1952 (A. B. Klots & R. D. Bird)
1961 (F. H. & P. W. Chermock)	
1963 (F. H. & P. W. Chermock)	
1967 (J. A. Ebner) ¹	1968 (C. S. Quelch)
1969 (A. E. Brower)	1969 (J. H. Masters) ²
	1970 (J. H. Masters)
	1970 (C. McCullough) ²
1971 (C. D. Ferris)	1974 (D. Oosting & D. Parshall)
	1976 (D. Oosting & D. Parshall)
	1978 (J. Troubridge)

¹ Specimens presumably not taken by Ebner personally.² Expeditions in late July and August, too late in the year to expect to find *Boloria polaris*.

27 collecting expeditions. These data are tabulated in Table 1. Information was gleaned from 14 expeditions to Churchill in odd-numbered years; 13 of which recorded *B. polaris* (only my very short trip in late July 1969 did not). On the other hand, I have documented 13 expeditions to Churchill in even-numbered years, none of which recorded *B. polaris*, even though 12 of them were at the proper time of year. I have also scanned both private and institutional collections for specimens of *B. polaris* that might have been collected at Churchill in even-numbered years, and have failed to find a single specimen. The evidence is thus conclusive, albeit circumstantial, that *Boloria polaris* has an odd-year only biennial flight at Churchill.

Additional records of *Boloria polaris* accumulated from other localities suggest that it is probably biennial everywhere, but may be subject to random geographic alternation of odd-year and even-year broods. These data are summarized in Table 2. Unfortunately, no other region in the arctic has been collected as extensively as Churchill for butterflies, over so long a period, and a comparable documentation of the biennial flight of *B. polaris* at any additional locality cannot be made. The collecting reports of the Alaska Lepidoptera

TABLE 2. Circumpolar capture records of *Boloria polaris*, noting year of capture. Records, other than Churchill, based on specimens in the American Museum of Natural History, New York and Carnegie Museum, Pittsburgh.

Locality	Odd-year captures	Even-year captures
Norway: Maalselvin	1923, 1935, 1937, 1939, 1971	
Finland		1934, 1936, 1946
Alaska:		
Eagle Summit & Mt. McKinley	1931, 1933, 1955, 1961, 1969, 1971	
Nome		1968
Yukon: Haines Junction		1966, 1968
British Columbia: Atlin & Summit Lake		1930, 1966
Mackenzie: Mackenzie Delta & Coppermine		1942, 1966
Keewatin: Baker Lake & Eskimo Point		1952, 1956, 1966, 1968
Manitoba: Churchill	1933, 1937, 1939, 1941, 1943, 1947, 1951, 1961, 1963, 1967, 1969, 1971	
Greenland	1957 ¹	1922, 1926, 1932, 1958
Baffin Island	1925, 1934	1896, 1954

¹ One specimen 22 July 1957 by A. T. Washburn.

Survey, over a ten year period (1967–1977) establish reasonably well, however, the biennial flight of the species on Ester and Murphy Domes near Fairbanks, Alaska.

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FOODPLANT OF ALPINE *EUPHYDRYAS ANICIA* (NYMPHALIDAE)

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ABSTRACT. Alpine *Euphydryas anicia* use *Besseyia alpina* as their foodplant during pre- and post-diapause development.

Until 1974 the foodplant of alpine *Euphydryas anicia* Doubleday & Hewitson was unknown. Discovery of the use of *Besseyia alpina* Rydberg (Scrophulariaceae) by a population at Cumberland Pass (Gunnison Co., Colorado) was mentioned by Ehrlich et al. (1975). My purpose here is to document the more widespread use of this plant by alpine *E. anicia* and to elicit observations by other workers in the field.

Figure 1 shows the distribution of alpine populations investigated to date. Table 1 shows evidence for the use of *B. alpina* by these populations. At the present time two things are known about alpine *E. anicia* populations: first, they occur on almost every peak above 3,660 m elevation above sea level in Colorado; second, the oviposition plant and post-diapause larval foodplant is *B. alpina* for all populations studied.

Unfortunately, we know nothing of the factors that limit the sizes of populations of alpine *E. anicia*, though we have learned something of their movement patterns (Cullenward et al., 1979). Since slow-melting snowbanks make early access to the alpine very difficult and since larvae are difficult to find, few post-diapause larvae have been collected. A few parasitoids have been reared from the 70 larvae collected to date. These are currently being identified. Few observations have been made on these larval populations in August and none in September, when predation and starvation of pre-diapause larvae might be seen. One can, however, infer something about the plant-herbivore relationship by observing the distribution and habit of plant growth and the magnitude of post-diapause feeding damage (Table 1).

Besseyia alpina is perennial and strictly alpine, known from 3,500 to 4,350 m in Wyoming, Utah, Colorado and New Mexico. The distribution often includes points of greatest local elevation (sites 1, 3, 11, and 12), but often does not, apparently due to lack of soil just beneath the scree at some of these points. Often the plants grow right up to edge of exposed ridges and sometimes on the ridge tops themselves.

In general, the sparse populations of *Besseyia* that are often prostrate in form and hidden among rocks suffer less feeding damage than

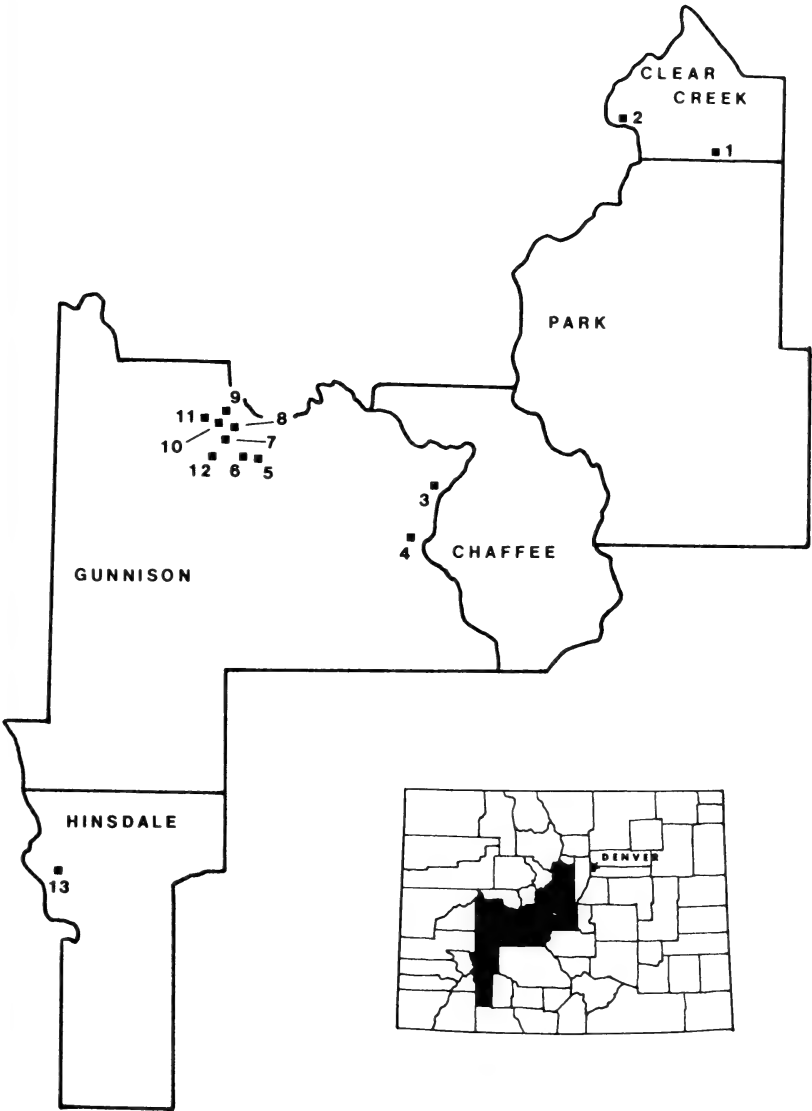


FIG. 1. Map of Colorado showing peaks investigated. Names on map refer to counties. 1, Mt. Evans; 2, Loveland Pass; 3, Cottonwood Pass; 4, Cumberland Pass; 5, Double Top; 6, Crested Butte; 7, Gothic Mtn.; 8, Avery Peak; 9, Mt. Bellview; 10, Mt. Baldy; 11, Cinnamon Mtn.; 12, Ruby Peak; 13, Rock Ridge.

TABLE 1. Distribution and habit of *Besseyia* growth, with post-diapause feeding damage. Locality numbers refer to Fig. 1 map.

Locality	Proportion of crop consumed by post-diapause larvae	Number of egg masses found	Number of post-diapause larvae	Number of plants sampled	Plant density	Plant habit	Food plant?
1	0.002	0	0	125	very sparse	1	No
2	0.007	0	0	299	sparse	1	No
3	—	2	0	50	sparse	2	Yes
4	0.09	23	15	1,000	dense in places	3	Yes
5	0.01	0	0	130	very sparse	1	No
6	0.15	0	0	6	very sparse	1	No
7	0.04	3	1	130	sparse	2	Yes
8	0.02	0	0	172	common in places	3	No
9	0.08	2	1	102	common	3	Yes
10	0.06	1	2	114	common in places	3	Yes
11	0.09	5	3	100	common over a small area	3	Yes
12	0.09	3	1	222	common	3	Yes
13	0.06	4	2	132	common	2, 3	Yes

Plant habits: 1—among rocks, small and prostrate; 2—in scree, but not inconspicuous; 3—in the open, erect.

do the denser, more conspicuous populations. Three alternative hypotheses may explain this phenomenon: first, some environmental variable may curtail both plant and butterfly growth; second, the butterflies may not be able to generate large populations where the plants are scarce due to some factor other than the butterfly itself; third, the butterflies may cause the observed pattern by over-grazing conspicuous populations of *Besseyia*. Further work is planned to learn which of these hypotheses is correct.

The magnitude of pre-diapause larval feeding damage and therefore its importance to the *Besseyia* populations remains unknown. The magnitude, however, is likely to exceed substantially that of post-diapause feeding damage (Table 1). The eggs are laid in clusters of 50–100, so a large number of larvae feed on a single plant. The larvae must reach a diapause weight of 5–10 mg each. Since the conversion rate of *Besseyia* biomass to larval biomass is probably about ten to one (White, 1973), each brood may consume 2.5–10 g [(50–100) × (5–10) × (10)] of *Besseyia*. This amount, according to a small sample of *Besseyia* leaves, is comparable to the size of the average *Besseyia* plant (2.7–9.5 g, varying by year and by population). Pre-diapause larval growth appears to be so slow at these elevations that significant plant growth

might occur during the feeding period. Thus, pre-diapause feeding might usually be completed on a single plant without larval migration or its consequent starvation. Since it appears that *Besseya* plants either bloom and set seed early in a growth season or not at all that season, larval feeding during the growing season does not affect seed set in that year. Sufficient defoliation in one year may suppress seed set in the future or may cause death of the plant. About 20% of the plants set seed in a given year. Presumably this proportion varies with a number of factors, including the extent of defoliation.

One frequently finds significant numbers of both sexes of *E. anicia* flying 100–300 m below the lowest part of *Besseya* distribution (sites 4, 5, 7, 8, and 12) and sometimes some distance away. Mark-release-recapture work at Cumberland Pass (site 4) showed that at least several hundred individuals fly in, and tend to stay in, an area several hundred meters from the nearest *Besseya*. At Double Top (site 5) numerous individuals occupy large areas apparently devoid of *Besseya*. Also, at some alpine sites (1, 2, 5 and 8 of Fig. 1) where *E. anicia* is known to maintain populations, no egg masses were found on *Besseya* and feeding damage was light. Why these things should be so if these populations are utilizing *Besseya* and represent the same ecotype as do the others remains mysterious. One can only suspect that superficially similar local populations are in fact ecologically rather heterogeneous.

ACKNOWLEDGMENTS

I thank Dr. Paul R. Ehrlich for his encouragement and Dianne Stewart for technical assistance. This work was partially supported by a grant from the Old Dominion University Research Foundation and was carried out from a base at the Rocky Mountain Biological Laboratory in Gothic, Colorado.

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FOURTH ADDITION TO THE SUPPLEMENTAL LIST OF MACROLEPIDOPTERA OF NEW JERSEY

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ABSTRACT. Additional species, subspecies and named aberrations (with larval food plant, when known) are added to the list of Macrolepidoptera of New Jersey not recorded in John B. Smith's Report of the New Jersey State Museum (1909) or in my later reports to date (1965, 1968, 1973, 1976).

The following new additions were collected by the author, Dr. C. Brooke Worth, Dr. Dale Schweitzer, and the Department of Agriculture at Rutgers University. References are cited for those species already reported elsewhere in the literature.

In this area, light pollution appears to be the main reason for the decrease in moths. The only collecting locality known to me where lights and bait still work is Dr. Worth's farm at Eldora, (Cape May Co.). This area is relatively isolated, since the land mass is on a peninsula. Most sphingids, saturniids and other conspicuous Lepidoptera formerly common throughout the state are still found here in large numbers.

Checklist numbers and classification for moths are taken from McDunnough (1938), updated to current nomenclature. Localities, dates of collection, collector (and when known, foodplant) are shown. Specimens not followed by the name of the collector were taken by the author. Specimens collected at Eldora, Cape May Co., were collected by the author in collaboration with Dr. Worth.

ACKNOWLEDGMENTS

I wish to thank Dr. Frederick Rindge and Eric Quinter, of the American Museum of Natural History, for determining some of the following specimens and for reading the manuscript, and Dr. Rindge for providing references to published records.

MOTHS

Arctiidae

Holomelina Herrich-Schaeffer

1022 *opella* form "belmaria" Ehrman

Eldora, 17 June; 17 Sept.

Dandelion, *Taraxacum officinale*; plantain, *Plantago major*

Noctuidae

Noctuinae

- Graphiphora* Ochseneheimer
1525 *tenuicula* Morrison
Drakestown, 17 Sept., Rutgers

Hadeninae

- Leucania* Ochseneheimer
1978-1 *linda* Franclemont
Long Valley, 21 July, Rutgers

Cuculliinae

- Metaxaglaea* Franclemont
2227-2 n. sp.
Eldora, 16 Oct., 25 Nov., 1, 11 Jan.
American holly, *Ilex opaca*

Amphipyryinae

- Apamea* Ochseneheimer
2328-1 *inebriata* Ferguson
Lakehurst, 8 April, 29 June, 25 July, Lemmer; Jerseyville, 9 July, Shulgin; Freehold, 17 July, Franclemont
- Agroperina* Hampson
2373 *lutosa* Andrews
Woodglen, 25 April, 2 July, Rutgers
- Luperina* Boisduval
2393 *passer* Guenée form "conspicua" Morrison
Drakestown, 21 Sept., Rutgers
Dock, *Rumex occidentalis*
- Oligia* Hübner
2421 *minuscula* Morrison
Lakehurst, 6 Sept., 15 Oct., C. Rummel
- Xylomoia* Staudinger
2434 *chagnoni* Barnes & McDunnough
Seabrook, 12 June, Rutgers
Borer in *Phalaris arundinacea*
- Callopietria* Hübner
2538 *floridensis* Guenée
East Millstone, 27 Sept., Rutgers
Ferns
- Platyperigea* Smith
2655 *multifera* Walker
Freehold, 25 June, Rutgers
2656 *extima* Walker
Freehold, 25 June, Rutgers
- Bellura* Walker
2709 *melanopyga* Grote
Camden, 25 May; Delanco, 26 May, Rutgers
Borer in yellow water lily

Acontiinae

Cryphia Hübner3100 *villificans* Barnes & McDunnough

Oliver, 12 June, Rutgers

Tarachidia Hampson3185 *semiflava* Guenée

Eldora, 20 May

Catocalinae

Catocala Schrank3336 *paleogama* Guenée, form "denussa" Ehrman

Hunterdon Co., 8 Sept., 9 Oct.

Hickory, *Carya*; walnut, *Juglans*3386 *gracilis* Edwards, form "lemmeri" Mayfield, 1923

Lakehurst, 1 Sept., Lemmer

*Vaccinium*3388 *herodias* Barnes & Benjamin, Gerhardi Benjamin & Barnes

Lakehurst, 15 July, Rutgers

3410 *micronympha* Guenée, form "lolita" SargentLebanon, *ex ovo* 3, 8, 18, 20, 22 June, 3 Sept.Red oak, *Quercus rubra**Zale* Hübner3493 *metata* Smith

Eldora, 20 May

Pinus virginiana

Ophiderinae

Metalectra Hübner3658-1 *richardsi* Brower

Eldora, 23 July

Hypeninae

Hypenodes Doubleday3728-1 *fractilinea* Smith

Martinsville, 10 June, Rutgers

Parahypenodes Barnes & McDunnough3729 *quadralis* Barnes & McDunnough

Hughesville, 25 July, Rutgers

Hermiinae

Epizeuxis Hübner3735 *concisa* Walker

Woodglen, 25 July; Evesboro, 9 July, Rutgers

Notodontidae

Heterocampa Doubleday3890 *varia* Walker

Chatsworth, 12 July, J. Madenjian

Oak, *Quercus* sp.

Geometridae

Larentiinae

Coryphista Hulst4248 *meadii atlantica* Munroe, 1954

Irvington, May–Sept., E. E. Witte

Barberry

Eupithecia Curtis4266-1 *slossonata* McDunnough, 1949

Eldora, 17 May

Hydriomena Hübner4477 *transfigurata* Swett. McDunnough, 1954

Lebanon State Forest, 13 June, Rutgers; Lebanon, 7, 13, 25 May

Ennominae

Lomographa Hübner4608 *glomeraria* Grote

Lebanon, 16 May

Hypomecis Hübner4738 *gnopharia* (Guenée)—formerly in *Pseudoboarmia*. Rindge, 1973

Eldora, 25 May, 18 June

Anacamptodes McDunnough4917-1 *humaria humaria* (Guenée). Rindge, 1966

Eldora, 20 May

General feeder on deciduous plants

Glenoides McDunnough4948 *texanaria* Hulst

Eldora, 24 Oct.

Epimecis Hübner4951 *virginaria* Cramer, form “*dendaria*” Guenée

Eldora, 20 May

Tulip tree, sassafras

Philgalia Duponchel4956 *strigataria* (Minot). “Melanic male.” Rindge, 1975

Lebanon, 5 April

4957 *denticulata* Hulst. Rindge, 1975

Orange Mts., Essex Co., 3 March, Lemmer. In Cambridge collection.

Tacparia Walker5024 *atropunctata* (Packard). Ferguson, “1973” (1974)

Near Lisbon, 12 June, J. Madenjian

Birch, *Betula* sp.*Sicya* Guenée5161 *macularia* Harrison

Lebanon, 17 July

Spirea, *Ceanothus*

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 RINDGE, F. 1966. Bull. Amer. Mus. Nat. Hist. 132: 216. (Fig. 7 [distribution map]; six localities from New Jersey).
 ——— 1973. Amer. Mus. Novitates No. 2514: 23. (Fig. 24 [distribution map]; five localities for New Jersey).
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 ——— 1975. *idem.* p. 128. (Fig. 76 [distribution map]; many New Jersey localities.)
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Errata

Corrections in Third Addition to the Supplemental List of Macrolepidoptera of New Jersey (1976):

- Page 197. No. 248. *polixenes* should read *polyxenes*.
 Page 197. Nyphalidae should read Nymphalidae.
 Page 198. *Meliana* Curtis = *Leucania* Ochsenheimer.
 Page 199. *Stabidium* Grote = *Plagiomimicus* Grote.
 Page 199. *Camptyllochla* Stephens = *Epizeuxis* Hübner.
 Page 199. 3777 should read 3735.
 Page 199. *Epicnaptera* Rambur = *Phyllodesma* Hübner.
 Page 200. Zanolidae = Apatelodidae.
 Page 200. No. 4932. Mistaken identity.

NEW STATUS FOR *EPIBLEMA MINUTANA* (KEARFOTT) AND NEW SPECIES OF *EPIBLEMA* HUBNER AND *SONIA* HEINRICH (TORTRICIDAE)

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ABSTRACT. *Epiblema minutana* is a distinct species, differing from *E. strenuana* (of which Heinrich considered it a synonym) in size, wing shape, male and female genitalia. *Epiblema luctuosana* is described from southern and eastern Texas. *Sonia paraplesiana* n. sp., widely distributed in the eastern United States, has long been confused with Zeller's *Sonia constrictana* known only from south Texas and south Florida.

Epiblema minutana (Kearfott) revised status

Eucosma minutana Kearfott 1905, Proc. U.S.N.M. 28: 356.

Eucosma antaxia Meyrick 1920, Exot. Microlepid. 2(2): 344.

Epiblema strenuana (Walker 1863) Heinrich 1923, U.S.N.M. Bull 123: 140.

Remarks. My interest in this problem was aroused when my wife and I took on North Padre Island, Texas, in March and again in June 1978, a series of specimens of an *Epiblema* which in Heinrich's key (1923, p. 137) keyed out at *strenuana*, but which, after examination of the female genitalia proved to be definitely different.

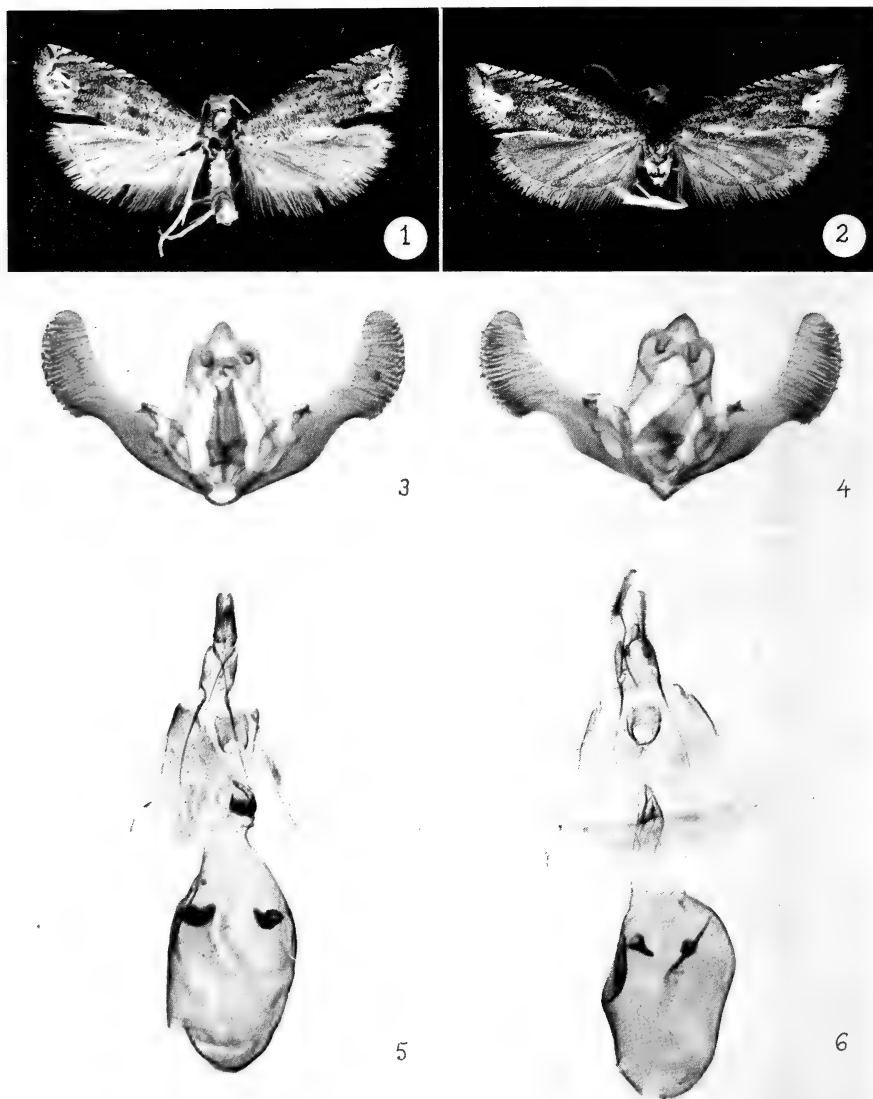
Kearfott's description of *E. minutana* states that *minutana* is of very much smaller size than *strenuana* and that the forewings are much narrower than *strenuana*—more than three times as long as wide. As our Padre Island specimens presented these two characters, I requested help of the National Museum of Natural History and the American Museum of Natural History which have most of Kearfott's types of *E. minutana*.

Kearfott described *minutana* from a series of about 40 specimens, 15 of which are before me: 9 from NMNH and 6 from AMNH. I eliminate from consideration one of the specimens borrowed from NMNH because, although labelled type by Kearfott, it does not appear to be conspecific with the other fourteen.

These fourteen types made a remarkably homogeneous group and my small, narrow-winged specimens from Padre Island, as well as some of my smallest "*strenuana*" go very well with them. Figs. 2, 4, 6, 9, and 10 permit easy comparison of Kearfott's types with some recently collected specimens. I do not include here a list of the Texas material examined in this study.

Description of female. Table 1 summarizes data for 22 dissected females. Among the females two characters are practically diagnostic: (i) the diameter at base of the signa, and (ii) the shape of the lamella postvaginalis. The signa are two hollow, curved, thornlike, sclerotized processes flattened at their distal end, round at their base. It is almost always easy to accurately measure their base diameter. Signa of both groups of specimens are about the same size, but they average larger (with no overlap in size) in *strenuana* than in *minutana*. The lamella postvaginalis is also consistently different. In *strenuana* it is longer in proportion to width and its sides are straight and parallel; in *minutana* the sides diverge caudad. Table 1 shows that there is overlap in forewing length as well as in forewing length-to-width ratio. The corpus bursae size and shape are not very good characters either, although the *minutana* corpus bursae may be more pear-shaped, less bulbous than that of *strenuana*.

Description of male. There appears to be little difference between males and females regarding wing size and forewing length-to-width ratio (Table 2). Some males will prove difficult to identify: size and length-to-width ratio are good characters if they do not fall in the range of overlap. When both these characters fail, one may rely on the size of genitalia or the shape of the valves: the neck incurvation of the valves of *minutana* is usually shallower than that of *strenuana*.



FIGS. 1-6: *Epiblema minutana*. 1, ♂ lectotype; 2, ♂ specimen from No. Padre Island, Nueces Co., 27 July 1978; 3, genitalia of lectotype, slide U.S.N.M. 24505; 4, genitalia of specimen of Fig. 2, slide A.B. 4473; 5, ♀ genitalia of lectoparatype, Montclair, New Jersey, July 8, slide U.S.N.M. 24501; 6, genitalia of a ♀ specimen from No. Padre Island, 8 July 1978, slide A.B. 4507.

TABLE 1. Comparison of measurements on dissected female specimens of *Epiblema minutana* and *E. strenuana*. Measurements are given as the median (and range).

Species	Forewing length ¹	Forewing length:width ratio	Corpus burae length:width ¹	Sigma base diameter ¹
<i>Epiblema minutana</i> , 11 specimens	5.6 (4.7-6.3)	3.1 (2.8-3.35)	1.15; 0.85 (0.95; 0.5-1.45; 1.0)	0.08 (0.07-0.11)
<i>Epiblema strenuana</i> , 11 specimens	7.8 (5.6-8.8)	2.65 (2.5-2.95)	1.45; 1.25 (1.0; 1.2-1.8; 1.25)	0.14 (0.12-0.18)

¹ Measurements given in millimeters.

Foodplant. The foodplant of *E. minutana*, according to Forbes (1923: 413) is *Ambrosia artemisiifolia* and I am convinced that, when better known, *E. minutana* will prove to be as widely distributed as its foodplant.

Type data. Lectotype, hereby designated, ♂, Montclair, New Jersey, 8 July. Genitalia on slide USNM 24505 (Figs. 1, 3 & 7). **Lectoparatypes:** ♀, Montclair, New Jersey, 8 July; left pair of wings and genitalia on slide USNM 24501 (Figs. 5, 8). ♂, Tryon, North Carolina, 23 May 1904, Fiske collector, right pair of wings and genitalia on slide USNM 24506. ♂, Tryon, North Carolina, 24 May 1904, Fiske collector, the metathorax and hind wings have, somewhat improperly, been glued. ♂, Cincinnati, Ohio, 10 July 1904, Annette Braun, abdomen missing. ♀, Plummer's I., Maryland, July, Aug. Busck, abdomen and antennae missing. ♂, New Brighton, Pennsylvania, 20 May 1903, H. D. Merrick, abdomen and some of both antennae missing. ♀, 440 L iss. 11 Jan. 1901, LHW missing. All of these are in NMNH. ♂, Essex County Park, New Jersey, 13 Aug.,

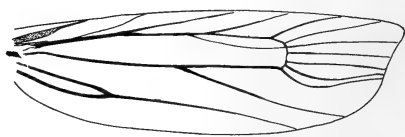
TABLE 2. Forewing measurements on fourteen of Kearfott's types of *Epiblema minutana*.

Type specimen		Forewing	
Museum	Sex & number	Length ¹ (mm)	Length-to-width ratio ²
NMNH	♂ 1 (USNM 24505)	4.9	3.3
	♂ 3 (USNM 24506)	5.6	3.55
	♂ 4	6.1	3.5
	♂ 5	5.5	3.5
	♂ 7	6.1	3.5
AMNH	♂ 1	6.1	3.2
	♂ 2	5.3	3.2
	♂ 3	4.9	2.95
	♂ 5	5.4	2.8
NMNH	♀ 2	5.4	3.45
	♀ 6	5.6	3.35
	♀ 8	6.1	3.2
AMNH	♀ 4	5.5	3.3
	♀ 6	5.4	3.25

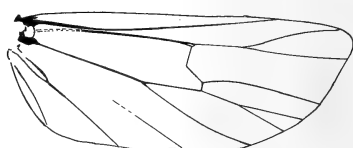
¹ Mean for males—5.55 m; for females—5.6 mm² Mean for males—3.25; for females—3.30



7



9



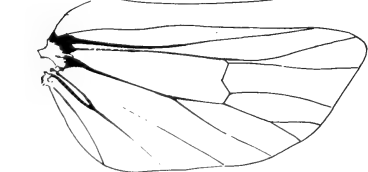
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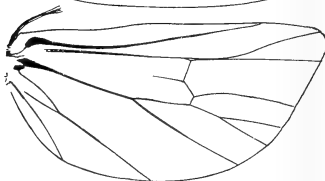
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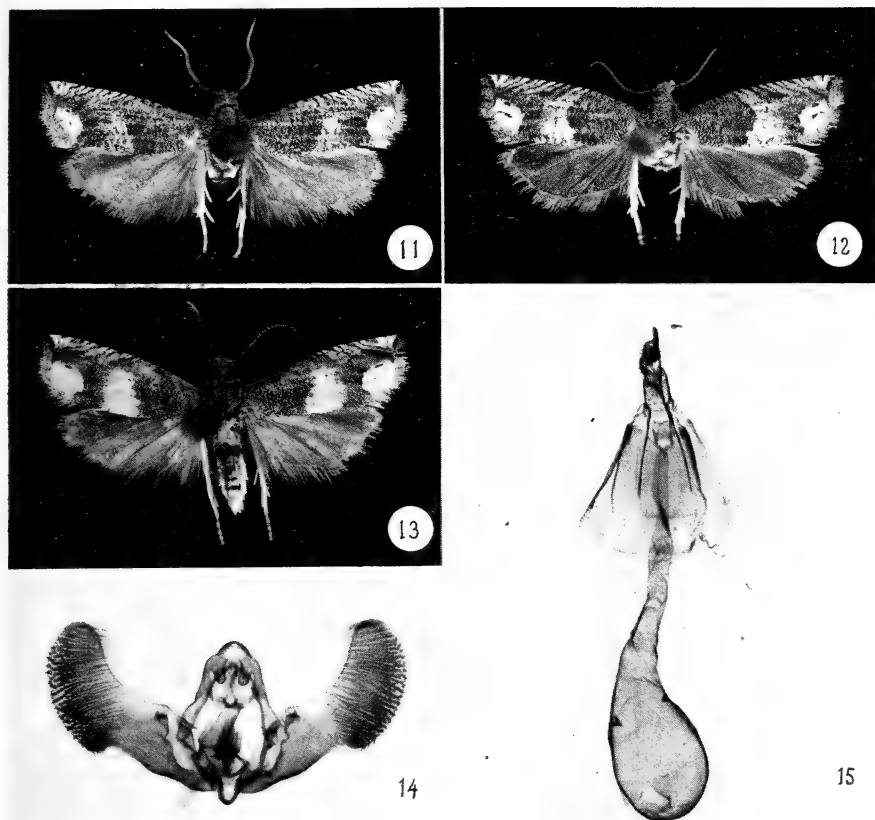
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17



FIGS. 7-10, 16, 17: *Epiblema* venation. Figs. 7-10: *E. minutana*, 7, ♂ lectoparatype, slide U.S.N.M. 24506; 8, ♀ lectoparatype, slide U.S.N.M. 24501; 9, ♂ from No. Padre Island, 6 April 1978, slide A.B. 4472; 10, ♀ from same date and location, slide A.B. 4465. Figs. 16, 17: *E. luctuosana*. 16, ♂ paratype from Padre Island National Seashore, 24 June 1976, slide A.B. 4269; 17, ♀ paratype of Fig. 15, slide A.B. 4521.



FIGS. 11-15: *Epiblema luctuosana*. 11, ♂ holotype; 12, ♀ paratype, No. Padre Island, 9 June 1978; 13, ♂ paratype, No. Padre Island, 5 June 1978; 14, genitalia of holotype, slide A.B. 4468; 15, genitalia of a ♀ paratype, No. Padre Island, 5 June 1978, slide A.B. 4521.

trap, W. D. Kearfott, in good condition, No. 34716. ♂, Essex County Park, New Jersey, 20 Aug., trap, W. D. Kearfott, head missing, otherwise in good condition, No. 34716. Essex County Park, New Jersey, 20 July, trap, W. D. Kearfott, abdomen missing, No. 34716. Female, Wilkesbarre, Pennsylvania, 6 June, W. D. Kearfott, genitalia on slide A.B. 4598. ♂, Montclair, New Jersey, u. m. s. 10 May, W. D. Kearfott, mildewed, Ac. 4667. ♀, Cincinnati, O., 18 June 1904, Annette Braun, traces of mildew, Ac. 4667. All six lectoparatypes are in AMNH.

Some material collected by A. & M. E. Blanchard, discussed above will be deposited in NMNH and AMNH. All the females collected by A. & M. E. Blanchard, described in Table 1 will (together with their genitalia slides) be deposited in NMNH.

I have been advised by a reviewer of this article that Richard L. Brown (1973:58) in his unpublished Masters thesis had already listed *E. minutana* as a species. It is a pleasure to give him credit here.

***Epiblema luctuosana* A. Blanchard, n. sp.**

Description. Palpi exceeding front by a little less than an eye diameter, third segment smoothly scaled, almost completely hidden in the loose, grayish scaling of the much longer second segment. Antennae simple, ciliate beneath, the sensory hairs hardly exceeding the scales. Male and female venation is shown in Figs. 16 and 17; maculation shown in Figs. 11, 12 and 13. Nearly all the scales, except the whitish ones of the ocelloid patch and those of the whitish patch at the middle of the dorsum are black or blackish basally, white or whitish distally, without appreciable transition: this is true, not only of the wing and body scales, but even of those which clothe the palpi, the antennae and the legs. It gives this insect a pepper-and-salt appearance which is most noticeable under the microscope at low magnification. The size and appearance of the ocelloid patch varies little but the whitish patch near the middle of the dorsum varies considerably, from very large (Fig. 13) to almost obsolete (Fig. 11), to completely obsolete. Hind wing dark fuscous.

Wing expanse: males 9.3–13.5, mean = 12 mm; females 11.8–13.6 mm, mean = 12.7 mm.

Male genitalia (Fig. 14). From the holotype, slide A.B. 4468.

Female genitalia (Fig. 15). Slide A. B. 4521, paratype from North Padre Island, Nueces Co., Texas, 5 June 1978. Ductus seminalis from ductus bursae somewhat closer to genital opening than to corpus bursae. Signa very small, conical.

Type data. Holotype (Fig. 11): ♂, North Padre Island, Nueces Co., Texas, 6 April 1978, genitalia on slide A.B. 4468 (Fig. 14), deposited in NMNH (type No. 75822).

Paratypes: (All localities in Texas) 3 ♀♀, Houston, 5–6 June 1968; ♀, Deutschburg, Jackson Co., 2 Aug. 1972; Santa Ana Refuge, 27 Nov. 1973, ♂; 4 Nov. 1974, ♂; Sinton, Welder Refuge, San Patricio Co.; 30 June 1975, ♀; North Padre Island, either Nueces Co., or National Seashore, Kleberg Co., 22 April 1976, ♂; 19 May 1976, ♂, 4 ♀♀; 24 June 1976, 2 ♂♂; 19 July 1976, ♂; 20 May 1977, ♂; 18–21 June 1977, 3 ♂♂, 3 ♀♀; 6 April 1978, 2 ♂♂; 5–10 June 1978, 16 ♂♂, 9 ♀♀; ♂, Conroe, Camp Strake, Montgomery Co., 14 Sept. 1977; ♀, Eagle Lake, Attwater Prairie Chicken Refuge, Colorado Co. The paratypes are in the author's collection.

I am indebted to Richard L. Brown for examining some of my specimens and slides and I quote him (*in litt.*) regarding the relationships of *luctuosana* to other *Epiblema* species: "*E. luctuosana* appears to be related with the species *numerosana* (Zeller), *praesumptiosa* Heinrich, *grossbecki* Heinrich, *abruptana* (Walsingham) and *deflexana* Heinrich. This group of species lacks sclerotization of the female ductus bursae (female of *deflexana* not examined) and has longer coronal setae on the cucullus relative to other *Epiblema* species. This group is also characterized by the vinculum depth exceeding the tegumen length and the presence of black scales on the labial palpi. *E. luctuosana* shares the above characters with this species group, but is distinguished by the absence of black scales on the labial palpi."

***Sonia paraplesiana* A. Blanchard, n. sp.**

Head. Front clay yellow; vertex pale brown; first and second segments of palpi shaggily squamous underneath, with a laterally compressed brush of long, clay yellow, brown dotted scales; third segment smoothly scaled, more than half hidden in scaling of second segment, brown with clay yellow tip. Antennae simple, shortly pubescent, brownish.

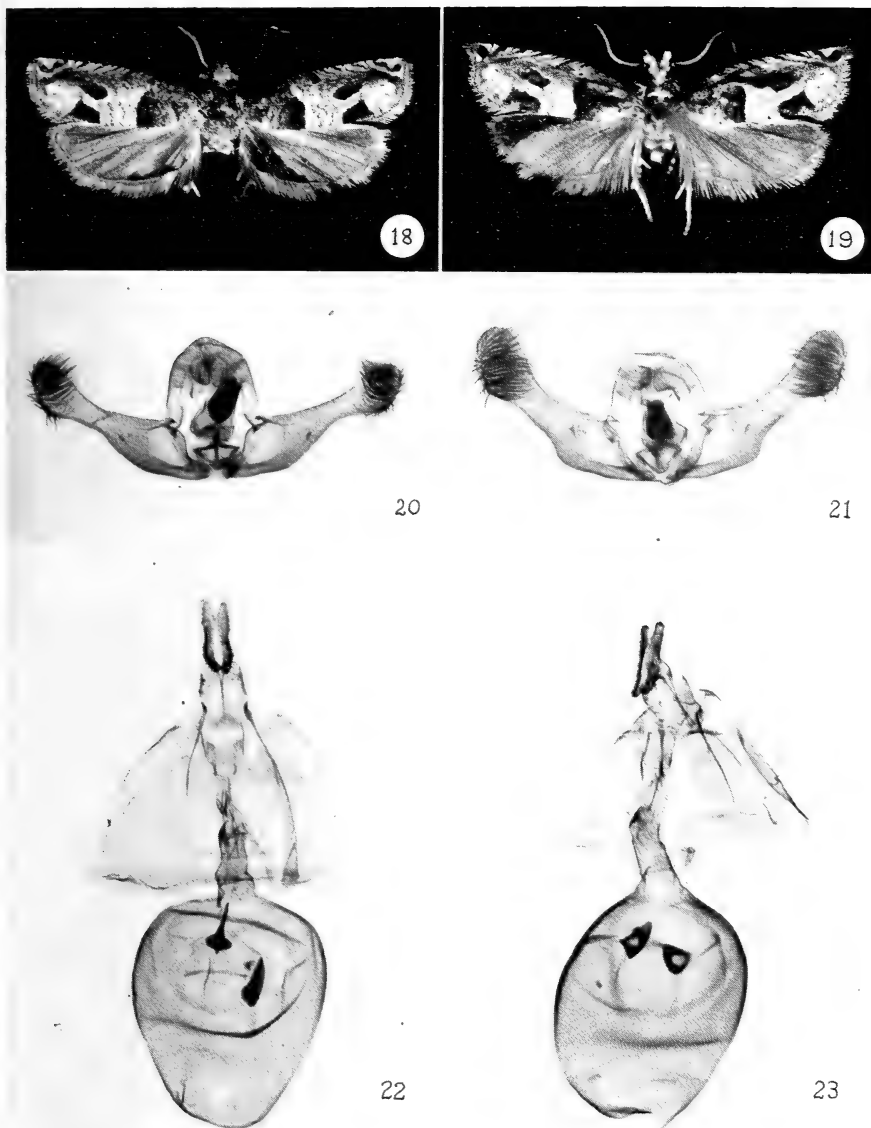
Maculation. As in Fig. 18, the color from dark fuscous brown to similarly tinted whitish. Wing venation: Figs. 24 and 25; the length of the stalk of veins R_5 and M_1 of the hind wing varies from short to about half as long as their free parts, but these two veins appear to be consistently stalked.

Wing expanse. 12.5–17 mm.

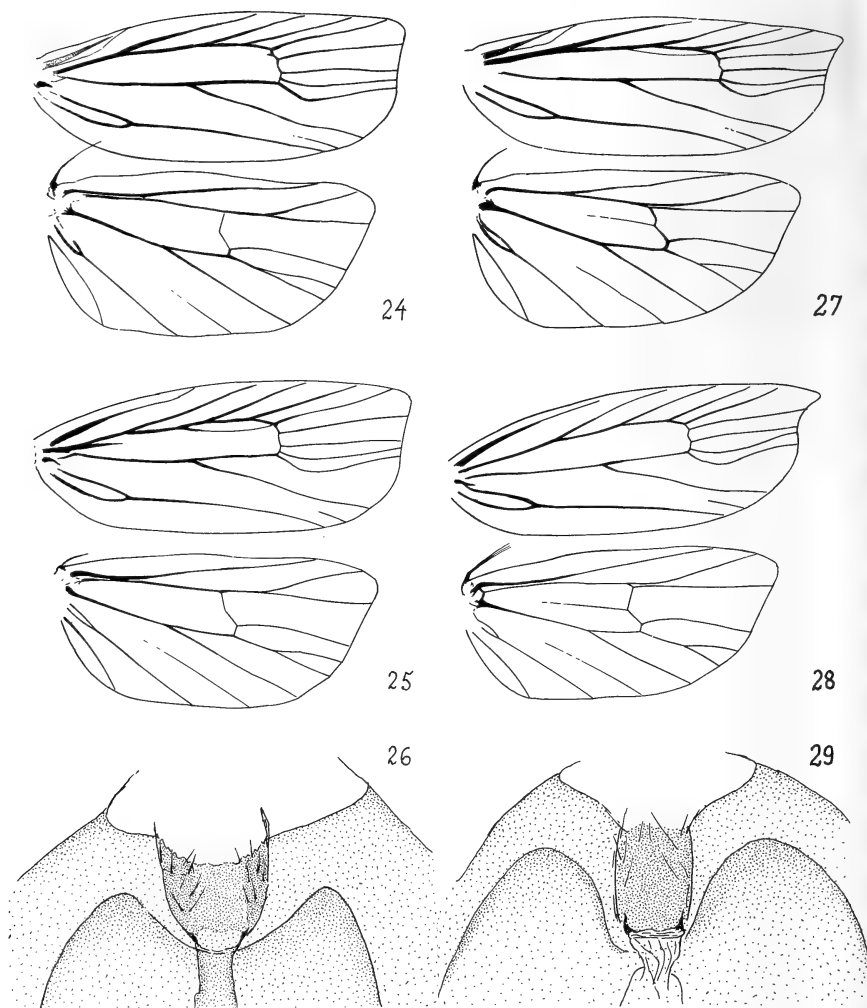
Male genitalia. As in Fig. 20.

Female genitalia. As in Figs. 22 and 26.

Type data. Holotype: ♂, Houston, Texas, 5 June 1968, genitalia on slide A.B. 4365,

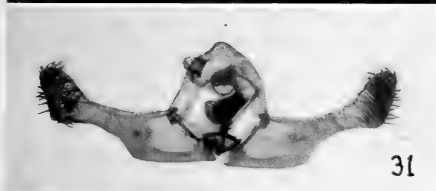
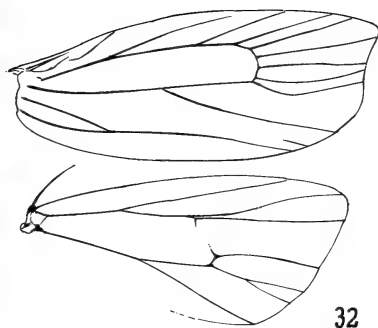


FIGS. 18–23: *Sonia* species. Figs. 18, 20, 22: *S. paraplesiana*. 18, holotype; 20, ♂ genitalia of a paratype, Houston, Texas, 8 June 1968, slide A.B. 4524; 22, ♀ genitalia of a paratype, Sinton, Texas, Welder Wildlife Refuge, 2 June 1978, slide A.B. 4512. Figs. 19, 21, 23: *S. constrictana*. 19, ♂ from Welder Refuge, 30 June 1975; 21, ♂ genitalia of a specimen from Santa Ana National Refuge, Texas, 15 September 1974, slide A.B. 4523; 23, ♀ genitalia of a specimen from Welder Refuge 30 June 1975, slide A.B. 4520.



FIGS. 24-29: *Sonia* species. Figs. 24, 25: *S. paraplesiana* venation. 24, ♂ paratype, slide A.B. 0892; 25, ♀ paratype, slide A.B. 4512. Figs. 27, 28: *S. constrictana* venation. 27, ♂, slide A.B. 4283; 28, ♀, slide A.B. 4358. Figs. 26, 29: lamella postvaginalis: 26, *S. paraplesiana*, ♀ paratype, slide A.B. 4512; 29, *S. constrictana*, ♀, slide A.B. 4360.

deposited in NMNH, No. 76098. **Paratypes:** Houston, Texas, 21 June 1966, ♂; 26 August 1966, ♂; 7 November 1966, ♂; 4, 5 June 1967, 2 ♂♂; 5-8 June 1968, 7 ♂♂, ♀; ♀, Sinton, Welder Wildlife Refuge, San Patricio Co., Texas, 30 June 1975; ♀, Town Bluff, Tyler Co., Texas, 15 Sept. 1975; 2 ♂♂, Tennessee Colony, Anderson Co., Texas 25 June 1978; A. & M. E. Blanchard collectors. Specimens presently are in the author's collection.



FIGS. 30-32: *Sonia constrictana*. 30, ♂ holotype; 31, genitalia, slide V. Adams XII.4.69; 32, venation of right pair of wings, same slide.

The following paratypes are in the National Museum: Putnam Co., Illinois, 26 June 1964, ♂; 2 July 1964, ♂; 1 July 1965, ♂; 25 June 1966, ♂; 7 July 1970, ♀; M. O. Glenn collector. 2 ♂♂, Cornell University, Ithaca, New York, 16 June 1957, D. R. Davis collector. ♂, McLean Bogs Reserve, Tompkins Co., New York, 20 July 1957, J. G. Franclemont collector. ♂, Long Island, New York, no date, Coll. G. P. Engelhardt. Martha's Vineyard, Mass., no date, ♂; 17 Aug. 1943, ♂, F. M. Jones collection. ♂, ♀, Oak Station, Alleg. Co., Pa., 4-5 Aug. 1908, Fred Marloff collector. Oneco, Manatee Co., Florida, 28 March 1954, ♀; 23 March 1957, ♀; ♂, Archbold Bio. Sta., Highlands Co., Florida, 27 March 1959, J. G. Franclemont collector. Same location, 28 March 1959, ♂; 30 April 1964, 3 ♂♂, 3 ♀♀, R. W. Hodges collector.

North Oaks, Ramsey Co., Minnesota, 7 July 1965, ♂; 16 July 1965, ♂; 20 August 1965, ♂; W. E. Miller collector, in North Central Experiment Station, Saint Paul, Minnesota. ♂, Livingston Co., Michigan, 22 July 1946, John H. Newman collector, in Michigan State University. Bay City State Park, Bay Co., Michigan, 17 July 1935, ♀; Midland Co., 15 July 1935, ♂, A. Olson & L. K. Gloyd collectors, in University of Michigan.

Remarks. Nineteen slides, including nineteen genitalia and ten pairs of wings, have been prepared. These were compared with eighteen slides, including eighteen genitalia and eight pairs of wings, of *Sonia constrictana*.

Sonia paraplesiana is extremely close to *Sonia constrictana* described by Zeller (1875) from a single male, now in the Museum of Comparative Zoology. This holotype bears the following labels: 1, Dallas, Texas, Boll; 2, a green label with the hand-written name *Paedisca* (?) *constrictana*; 3, MCZ type No. 14335; 4, Wings and genitalia on slide V. Adams XII.4.69.

Sonia paraplesiana closely resembles *S. constrictana*. Zeller's type (its genitalia and venation as in Figs. 30, 31, 32) respectively agrees very well with Figs. 18, 20 and 24.

The main characters by which the two species can be differentiated are as follows:

the outer margin of the forewing of *paraplesiana* is slightly concave between veins M_1 and Cu_1 and the apex is broadly rounded; in *constrictana* the outer margin is more concave between the same veins and the apex is pointed. *Sonia constrictana* shows near the apex of the forewing a small ocellus-like spot which on the better marked specimens is blackish and surrounded with yellowish brown. *S. paraplesiana* is normally darkened at the apex of the forewing, but there is no ocellus-like spot there. Veins R_s and M_1 of the hind wing are stalked in *paraplesiana* and the length of the stalk varies from very short to half as long as the free part of these veins. In *constrictana* these veins vary from contiguous to separate and closely parallel for some distance out of the cell.

The tegumen length of the male genitalia is about equal to the vinculum depth in *constrictana*, and greater in *paraplesiana*; the ventral margin of the valva has a shallow neck incurvation in *paraplesiana*, the neck incurvation is deeper in *constrictana* and basad of it the margin is bluntly angled. In the female genitalia, the lamella postvaginalis of *paraplesiana* is wider than long and its margins diverge caudad; it is narrower than long in *constrictana* and its margins are subparallel. The ventral signum of *paraplesiana* is caudad of the dorsal one, they are at about the same level in *constrictana*. The signa of *constrictana* appear on average, bigger than those of *paraplesiana*.

Distribution. *Sonia paraplesiana* probably inhabits the territory which was indicated by Heinrich for *Sonia constrictana*: Florida, Texas, North Carolina, Kentucky, Illinois, Iowa, South Dakota, District of Columbia, Pennsylvania, New Jersey. We can now add Massachusetts, Michigan, Minnesota, and New York. *Sonia constrictana* is more southern: except for one specimen from Putnam Co., Illinois (M. O. Glenn, 1 August 1970, in NMNH), I have seen only specimens from Florida and Texas, where it is sympatric with *paraplesiana* and where both species are sometimes taken together.

ACKNOWLEDGMENTS

This paper was made possible through the kind cooperation of many people: Dr. J. F. G. Clarke, Dr. F. H. Rindge, Dr. R. Silberglied, Dr. W. E. Miller generously responded to my request for specimens and types. I am also indebted to Richard L. Brown for comparing some of my specimens with those in the National Museum and for several useful comments. I am particularly grateful to Dr. Clarke for his continued interest and support in this project.

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SIX NEW STATE BUTTERFLY RECORDS FROM KENTUCKY¹

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ABSTRACT. Six species of butterflies are added to the Kentucky state list, and collection data are given. They include *Euphyes dion dion* (Edwards), *E. dukesi* (Lindsey), *Erynnis lucilius* (Scudder and Burgess), *Calephelis muticum* McAlpine, *Leptotes marina* (Reakirt), and *Lethe portlandia* (Fabricius) (subspecies *missarkae* Heitzman and dos Passos). A second state record of *Poanes viator* (Edwards) is also reported, probably representing subspecies *zizaniae* Shapiro. The Kentucky butterfly fauna now numbers 131 species.

The Kentucky Lepidoptera Survey was begun in 1964 with the goal of characterizing as completely as possible the Lepidoptera fauna of Kentucky through collection of records and specimens of butterflies and moths from the Bluegrass State. In a preliminary checklist of butterflies, Covell (1974) listed 123 species on record as of that year. Two species have been added more recently to the state list through published reports: *Amblyscirtes belli* Freeman (Henderson, 1976) and *Celastrina ebenina* Clench (Wagner and Showalter, 1976). While many exciting discoveries have been made with regard to butterfly species in Kentucky, notably the discovery of a substantial colony of *Erora laeta* (Edwards) in Harlan Co., this paper is confined to the formal report of six additional butterfly species. These additions bring the Kentucky list to 131.

Euphyes dion dion (Edwards)

Two males were collected on flowers of *Trifolium hybridum* L. at the northern edge of Reelfoot Lake National Wildlife Refuge, Fulton Co., Kentucky on 29 May 1977, by Gibson and Henderson (one each). The site was an extensive grass and sedge marsh within a mile of the Tennessee border. *Poanes viator* (Edwards) was also taken there on that date, a second state record of the species; it probably represents subspecies *zizaniae* Shapiro.

¹ Contribution No. 194 (New Series) of the Department of Biology, University of Louisville.

Euphyes dukesi (Lindsey)

One male specimen of the Dukes' Skipper was found by Covell while examining the collections of the Biology Department, Western Kentucky University at Bowling Green. The specimen was taken by student Melinda Johnson in Webster Co., Kentucky on 6 July 1972. Efforts to locate the student to learn a more precise locality have not yet been successful. Webster County has much wet meadow habitat appropriate to *dukesi* populations. The specimen is now in the University of Louisville collection.

Erynnis lucilius (Scudder and Burgess)

Gerald Straley first reported this skipper from a site 7 mi W of Irvine, Estill Co., Kentucky, taken 20 April 1974. However, positive identification has not even now been made. Another possible collection reported by Straley was taken by him and W. H. Wagner, Jr. 1.2 mi S of Stanton on Route 213, Powell Co., 21 April 1974. Gibson took 4 males and a female in close proximity to the foodplant, *Aquilegia canadensis* L. (columbine), along Route 316, Trimble Co., 20 June 1976. Another specimen was taken by Gibson in Bracken Co. amid extensive columbine on 24 April 1977. Although separation of *lucilius* from *baptisiae* is apparently almost impossible on morphological grounds (Burns, 1964: 185), we feel that the specimens taken close to columbine are very likely to be *lucilius*. Burns (1964) was hesitant to name specimens from the Appalachian region of Virginia, West Virginia, and Tennessee as *lucilius*, feeling that they were "better placed as *baptisiae*." We feel that this ecological evidence justifies including *lucilius* on the Kentucky list.

Calephelis muticum McAlpine

A male of the Swamp Metalmark was collected in Otter Creek Park, Meade Co., 11 September 1976, by Gibson. It was taken on a flower of tickseed sunflower, *Bidens aristosa* (Michx.) Britt., in a low, poorly drained meadow. Covell verified the initial determination on the basis of forewing shape, coloration, and genitalic features. The specimen is in the University of Louisville collection (C. V. Covell Male Genitalia slide No. 1088). This record extends the known range of *muticum* to the southeast from central Ohio. In the western extremity of its range it is known to occur as far south as Arkansas.

Leptotes marina (Reakirt)

One male of the Marine Blue was taken in Louisville, Jefferson Co., 31 July 1978, by McInnis, and was determined by Covell. The site was along Interstate Route 71 at Mockingbird Valley Road near

the Ohio River. Crown vetch and other legumes were growing in the area, but no more specimens were seen on several subsequent visits to the site. The obvious conclusion is that this individual was a stray. The specimen is in the University of Louisville Insect collection.

Lethe portlandia (Fabricius)

The number of *Lethe* species known from Kentucky is now 4 with the addition of a male and a female of *L. portlandia missarkae* Heitzman and dos Passos on 27 May 1978 by Gibson and Henderson. The locality was in flat lowland woods with cypress, oak, hickory, and abundant cane where Route 94 crosses Bayou de Chien, Fulton Co., Kentucky. *Lethe creola*, *appalachia*, and *antheson* have also been taken in that locality; the *creola* was abundant on 18 August 1978. The pair of *missarkae* was determined by Covell from the original description. This record marks a new northeastward extension of the known range of this subspecies, although its presence in Kentucky had been predicted by Heitzman and dos Passos (1974). The male is in the Gibson collection; Henderson has the female.

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A NEW GHOST MOTH FROM THE SOUTHERN APPALACHIAN MOUNTAINS (HEPIALIDAE)

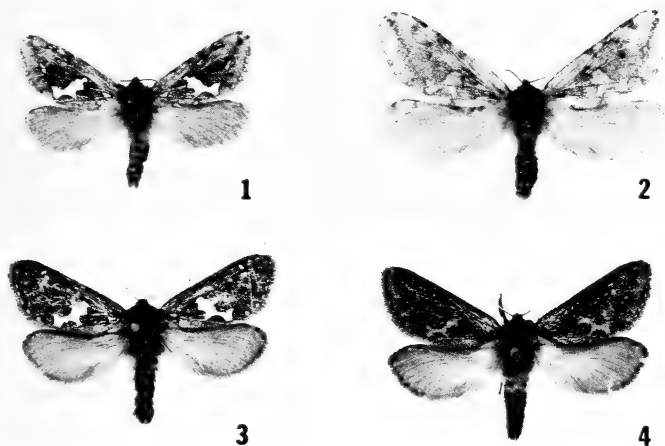
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ABSTRACT. *Hepialus sciophanes*, a new species from a high elevation habitat in Jackson Co., North Carolina, is described and illustrated. Its generic affinities are examined, leading to the conclusion that *Hepialus* as generally understood is heterogeneous. *H. sciophanes* belongs to the *hyperboreus* group of northern and western North America.

Among moths collected in a light trap at nearly 6,000 ft on Waterrock Knob, Jackson Co., North Carolina, in July 1974 were 19 specimens of a very distinct new hepialid, the first new species of this family to be described from North America since 1925. It belongs to the group that includes *Hepialus hyperboreus* (Möschler), *roseicaput* N. & D. (Holland, Pl. 41, Fig. 15, as *hyperboreus*), *pulcher* Grt., *mcglashani* Hy. Edw., and *mathewi* (Hy. Edw.), none of which occurs in the Southern Appalachians. *H. hyperboreus*, or a species resembling it, has been taken on Mt. Washington, New Hampshire, but the North Carolina species differs in color, pattern, and male genitalia. The small, relatively common eastern hepialid, *H. gracilis* Grt., easily distinguished by its smaller size and lack of conspicuous white patches, was the only other hepialid collected on Waterrock Knob.

In an effort to place the new species correctly, I investigated the European type-species of several genera but reached no satisfactory conclusion. Members of the *hyperboreus* group bear a vague resemblance to the type-species of *Phymatopus* Wallengren (*hecta* L.), having comparable although differently developed structures in the male genitalia. Their relationship to the type-species of *Hepialus* Fabricius (*humuli* L.) and *Korscheltellus* Börner (*lupulinus* L.) is less obvious. Indeed, the male genitalia of these European species and the American ones of the *hyperboreus* complex are so different that it is hard to determine whether some of the parts are even homologous. The new species and others of the *hyperboreus* group likewise differ structurally from *H. gracilis*, *H. mustelinus* Pack., and from their close Palearctic counterpart, *H. fusconebulosa* DeGeer. The latter are much closer to *humuli* and *lupulinus* in the form of all major genitalic components such as the tegumen, vinculum, valve and juxta, and agree in the long-stalked condition of $R_2 + R_3$ (almost to apex) in both wings. Until a much-needed generic revision of the Hepialidae is available, species of these several groups had best be referred to *Hepialus* in the broad sense.



FIGS. 1-4. *Hepialus sciophanes*: 1, holotype male; 2, allotype female; 3, paratype male, Waterrock Knob, 5,800 ft, Jackson Co., North Carolina, 16 July 1974, D. C. Ferguson; 4, paratype male, same data.

***Hepialus sciophanes*, new species**

Figs. 1-6

Description. **Venation** (Fig. 5) normal for group but differing from that of at least the most similar eastern species in two respects: R_2 and R_3 of both wings stalked for less than half distance from point of common origin to apex, and R_4 and R_5 unstalked beyond end of cell. In *hyperboreus* and *gracilis* $R_2 + R_3$ fork nearer apex, and R_4 and R_5 have a short stalk beyond end of cell.

Males with color and pattern of wings highly variable; basically light brown with diffuse darker brown lines and shading and a large, elongated white patch in median area of forewing, inclined obliquely toward tornus. However, over half the specimens show various degrees of melanism, some heavily suffused with black. Dark markings of **forewing** usually obscured, but when visible, consisting of an almost straight submarginal band from near tornus to apex, three costal markings which in higher Lepidoptera would be regarded as rudiments of antemedial, medial, and postmedial lines (in allotype a complete but indistinct medial band present), and diffuse, variable shading in basal and medial areas that does not resolve itself into definite markings. Pale markings of forewing consist primarily of the large, white or cream-colored, oblique, somewhat angulate medial patch, and secondarily of several much smaller whitish spots as follows: one or more near base, two or three beyond middle of costa, one or two on inner margin, one or two near mid-zone of submarginal band, one very small dot near middle of second anal vein, and a subterminal series of five dots. In half of the specimens the large white patch is reduced or obscured, and in only three are all white spots present. These white markings are clearly disconnected components of the pattern seen in more complete form in other species such as *H. hyperboreus*, *mathewi*, or *mcglashani*, and cannot be reconciled with the very different patterns of *H. gracilis* or *Sthenopsis auratus* Grt., the only other southern Appalachian species of comparable size. **Hindwing** light brown with thin yellowish costal and outer margins faintly spotted with brown between vein endings, or darker without yellowish border. **Underside** of light specimens brown, with markings of upperside in part showing through faintly

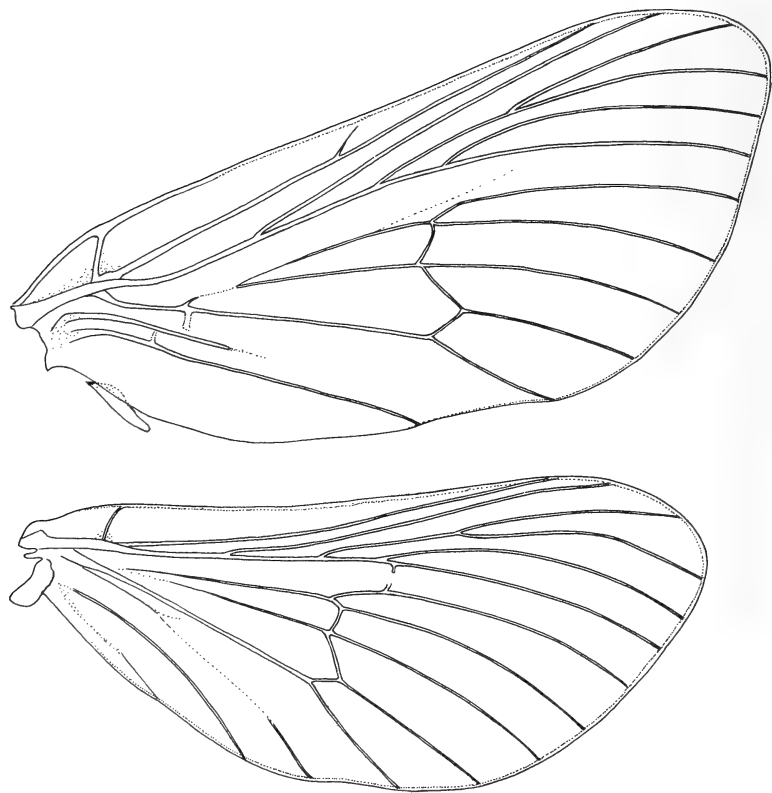


FIG. 5. *Hepialus sciophanes*: wing venation of male (paratype).

and with costal and outer margins somewhat yellowish; underside of dark specimens darker brown, usually without yellowish margins. The allotype, which is the only known female, is a lighter brown than most of the males, and its pale markings are suffused with gray. External structure of **head**, **antennae** and **legs** apparently similar to that of other Hepialidae mentioned.

Male genitalia as illustrated (Fig. 6). Valve well developed, two-lobed. Dorsal end of tegumen with pair of hairy lobes suggesting socii; a juxtalike plate between bases of valves, and a medial, basically membranous structure, resembling and probably functioning as an aedeagus, with a distinctive apical sclerite bearing a long, slender spine; the latter partly encircled by an elaborate, sclerotized structure, in function probably serving the dual role of gnathos and transtilla, although homologous with neither. Female genitalia not examined.

Length of forewing. holotype male, 15 mm; paratype males, 15–18 mm; allotype female, 20 mm.

Types. Holotype, male, Waterrock Knob, 5,800 ft, Jackson Co., North Carolina, 16 July 1974, D. C. Ferguson. Type No. 76,131, U.S. National Museum. Allotype, female, same data but collected 17 July. Paratypes, 17 males, same locality and collector, 16–17 July 1974. Paratypes deposited in U.S. National Museum, Canadian National Col-

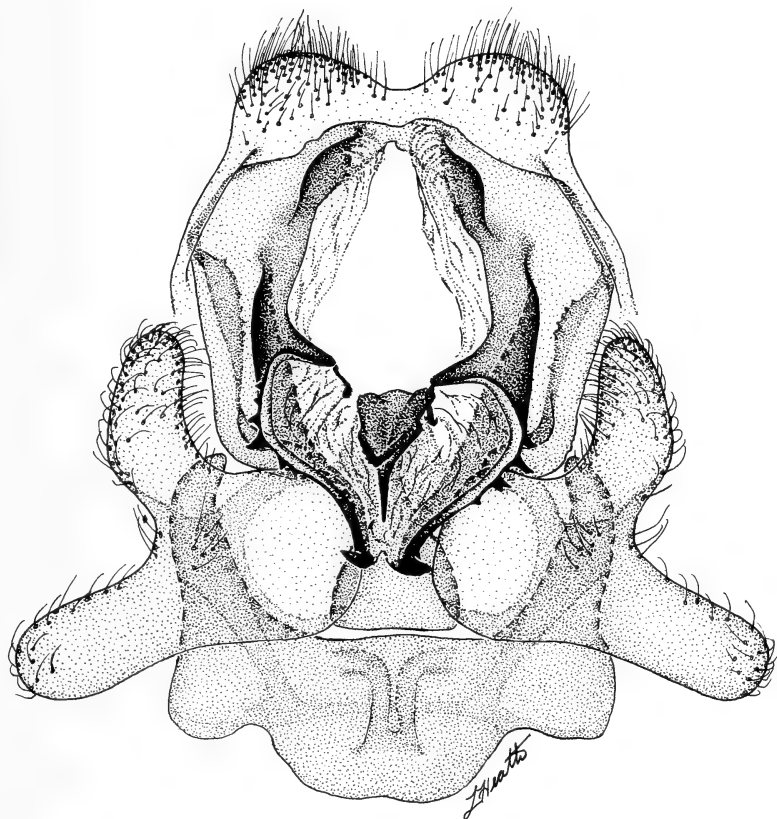


FIG. 6. *Hepialus sciophanes*: male genitalia (paratype).

lection, British Museum (Natural History), and the collection of Norman B. Tindale, Palo Alto, California.

Remarks. The type series was collected 500–600 ft S or SW of the Blue Ridge Parkway, opposite the entrance to the trail leading to the summit of Waterrock Knob, which is on the other side of the road. The trap was located in a grassy clearing, a small “bald,” on the mountain slope just outside of a large stand of Fraser fir and yellow birch that occupies the ridges and summits at that elevation and above. The vegetation in the immediate vicinity consisted mainly of grasses, ferns, *Vaccinium corymbosum* L., *Rhododendron* and *Viburnum* species.

Five species of Hepialidae occur in the southern Appalachians: *H. gracilis* (*H. mustelinus*, if indeed a distinct species, may also be there), *H. sciophanes*, *Sthenopsis auratus* (easily distinguished by the extensive gold or silvery markings on the forewing), *S. argenteomaculatus* (Harris), and another large species resembling *S. quadri-*

guttatus Grt., known from only one poor specimen from Gatlinburg, Tennessee. *Sthenopsis quadriguttatus* and *argenteomaculatus* were figured by Holland (Pl. 41, Figs. 13, 14). All of these are otherwise more northern species, or of northern affinity, reaching their southern limit in the mountains of North Carolina or Tennessee. No Hepialidae are known from the southeastern Coastal Plain or Piedmont.

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Journal of the Lepidopterists' Society
33(3), 1979, 196-197

GENERAL NOTES

A LIST OF LARVAE SUSTAINED ON WHEAT GERM DIET

A wheat germ diet has been formulated for the puss caterpillar (Khalaf 1974, Fla. Entomol. 57: 377-381). It consists of wheat germ, casein, sugar, salts, inhibitors, linseed oil, cholesterol, vitamins, antibiotics, and agar. Recently, the same diet was tested and found suitable for rearing various species of moths. All these, throughout this project, were collected as larvae from the field after feeding for variable periods on their natural host plants.

Young larvae of the following species utilized the diet for a period of ten days to a few weeks and then formed either cocoons or adults: the pyralids, *Evergestis rimosalis* (Guenée) and *Glyphodes pyloalis* (Walker); the notodontid, *Schizura unicornis* (J. E. Smith); the noctuid, *Spodoptera latifascia* (Walker); the arctiid, *Diacrisia virginica* (Fabricius); the yponomeutid, *Plutella xylostella* (L.); the cochlid, *Sibine stimulea* (Clemens); the lasiocampid, *Malacosoma disstria* Hübner; and the liparid, *Hemerocampa leucostigma* (J. E. Smith).

Mature larvae of the arctiid, *Estigmene acrea* (Drury), and the noctuid, *Spodoptera eridania* (Cramer) also utilized the diet for about one week or more and then formed cocoons or adults. More than ten specimens of *E. rimosalis*, *S. latifascia*, *D. virginica*, *S. stimulea* and *H. leucostigma* were reared on the diet. Only a few specimens of the rest of the species were reared. This diet was slightly modified, mainly by substituting corn oil for the linseed oil, and was used to rear the puss caterpillar (Khalaf 1975, Biology of the Puss Caterpillar and its Ichneumonid Parasite. Loyola Univ. Press, New Orleans, Louisiana. 43 p.). I have used the same modification to raise several other species of moths: 1) Recently hatched larvae of the noctuid, *Spodoptera eridania* (Cramer); and liparid, *Hemerocampa leucostigma* (J. E. Smith) utilized the diet and formed cocoons or adults. 2) Young larvae of the following species utilized the diet for a few weeks: the arctiid, *Epantheria scribonia* (Stoll), the notodontid, *Schizura unicornis* (J. E. Smith) and the noctuid *Spodoptera latifascia* (Walker). 3) Mature larvae of the following species also utilized the diet and formed adults: the lasiocampid, *Malacosoma disstria* Hubner; the arctiids, *Diacrisia virginica* (Fabricius), *Isia isabella* (J. E. Smith), and *Hyphantria cunea* (Drury); the noctuids, *Zale lunata* (Drury), *Acronicta arioch* Strecker, and *Xanthopastis timais* (Cramer); and the saturniid, *Automeris io* (Fabricius).

In rearing some of the species, e.g., *Sibine stimulea*, the diet seemed to interfere with cocoon formation. As the larvae became full grown, I found it was better to plate

only half of the floor of the rearing carton with the diet, leaving the other half clear for cocoon formation. In other cases, e.g., *Spodoptera latifascia* and *Estigmene acrea*, the mature larvae burrowed into the diet media for pupation. In time, the diet hardened and trapped the insect. For rearing such species, a special rearing carton must be prepared for mature caterpillars, half plated with diet and the other half containing soil for burrowing and pupating.

I am grateful to my students, P. A. Golden, F. J. Mueller, and T. M. Kelly for their help. I wish to thank R. W. Hodges, E. L. Todd, and D. M. Weisman of the Systematic Entomology Laboratory, U.S. National Museum, for the identification of the caterpillars. This investigation received support from the Academic Grant Fund of Loyola University.

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Journal of the Lepidopterists' Society
33(3), 1979, 197-198

"MUD PUDDLE CLUBS" IN PURE *COLIAS EURYTHEME* (PIERIDAE) IN NORTH CENTRAL CALIFORNIA

Clark (1932, Butterflies of the District of Columbia, pp. 154-155) and Clark & Clark (1951, Butterflies of Virginia, pp. 109-110) chronicled the invasion and establishment of the Orange Sulphur, *Colias eurytheme* Bdv., in the northeastern United States almost 50 years ago. They first suggested that "mud puddle" behavior originated in that species through introgressive hybridization with *C. philodice* Latr. Puddling by summer males of *C. eurytheme* was not observed for about ten years after that species invaded the Washington, D.C. area. Puddling is still much less common in *C. eurytheme* than in *C. philodice* in the northeast.

One of the few areas in North America where genetically pure *C. eurytheme* populations still exist is the Central Valley of California. The nearest *C. philodice* are east of the Sierran divide, north of Mount Shasta, or in the irrigated alfalfa-growing areas of southeastern California and Arizona (Emmel & Emmel 1973, Butterflies of Southern California, pp. 18-19). Even so, yellow individuals do turn up rarely in these populations. They were first noted by Hovanitz (1944, Genetics 29: 1-30) and do not seem to have increased in frequency in some 35 years, and their origin remains unexplained.

Although *C. eurytheme* often achieves extremely high densities in the Central Valley, I have been unable to find records of mud puddle aggregations and had never observed them myself until 26 May 1978. On that date 81 males were counted in four aggregations in a drying drainage ditch in Rancho Cordova, Sacramento Co., elevation about 10 m. The aggregations were found between 1455 and 1538 h along 2 km of ditch; all were in direct sunshine. They consisted of: (i) 10 *C. eurytheme*, 1 *Pieris rapae* L., 3 *Everes comyntas* Godart; (ii) 23 *C. eurytheme*, 1 *E. comyntas*; (iii) 38 *C. eurytheme*; (iv) 10 *C. eurytheme*, 1 *P. rapae*. All individuals were fresh males. Where more than one species was involved, each formed a compact group separate from the others. At another location about 3 km away a single male *P. rapae* was seen on a puddle about 1100. Mid-afternoon weather conditions were scattered to broken cirrus cloud; air temperature 24-27°C, relative humidity 30%; wind SW, ca. 15 km/h.

Nearby annual grassland, occupied by vast stands of a weedy annual *Vicia* (Leguminosae), was the scene of large-scale emergence of *C. eurytheme*. Virtually all of several hundred animals seen were fresh males. Many soft-winged individuals could be found, especially in the morning. A copulating pair, the female teneral, was found 150 m from the ditch at 1525.

Nectar sources were superabundant (blooming *Vicia*, *Brassica*, and *Centaurea*) and showed no sign of saturation despite the great numbers of butterflies flying. The sample of male *eurytheme* I collected from the puddles contained only large, deep orange, typical "summer" phenotypes. The water content of the vegetation was still high but beginning to decrease markedly, and the weather had been cooler than normal for a week. I have no hypothesis to account for the prevalence of puddling at this site on this date, but it does imply that the capacity to form such aggregations does exist in pure *C. eurytheme*.

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Journal of the Lepidopterists' Society
33(3), 1979, 198-199

LEPIDOPTERA FROM BOLUSES OF NESTLING CATTLE EGRETS IN EASTERN MISSOURI

The relatively recent immigration and rapid range expansion of the Cattle Egret (*Bubulcus ibis* (L.)) in North America (Crosby 1972, Bird-banding 43: 205-212) has elicited several studies on the feeding behavior and diet of this bird in the United States (e.g., Hanebrink & Denton 1969, Arkansas Acad. Sci. Proc. 23: 74-79; Fogarty & Hetrick 1973, Auk 90: 268-380; Jenni 1973, Auk 90: 821-826). The studies that have been published to date in the U.S.A. mainly provide only the family names of the arthropod prey species, and their only consensus relative to arthropods is that they are a major item in the diet of nestling Cattle Egrets. It seems logical to anticipate that more precise determinations of the arthropod species could help ornithologists designate certain of the prey species as indicators of portions of the adult Cattle Egret's foraging habitat and thereby more accurately interpret the bird's overall ecology and behavior.

As part of a preliminary study of the diet of nestling Cattle Egrets, Dr. Jean W. Graber, Illinois Natural History Survey, collected regurgitated boluses from a heronry containing ca. 300 active Cattle Egret nests on Billings Island in the Mississippi River, Scott Co., Missouri, on 30 June and 6 July 1975. Approximately 20 boluses were collected on each sampling date. They were preserved in 70 percent ethyl alcohol and subsequently examined by me for lepidopterous prey.

The two sets of boluses contained 45 caterpillars and 2 moths representing 9 species and 4 families (Table 1). The caterpillars in the boluses were in remarkably good condition thereby facilitating identification of most species. All except two of the caterpillars, *Leucania* sp. and the single pyralid, are known to be common in field crops in the midwestern part of the U.S.A. In fact, the species complex suggests that the caterpillars were captured by adult Cattle Egrets in a legume-grass habitat such as an alfalfa (*Medicago sativa* L.) or soybean (*Glycine max* (L.) Merr.) field. The geometrid moth, *Haematopis grataria* Fabricius, frequently may be encountered in short, mixed herbaceous habitats, e.g., weedy pastures and crop borders (pers. obs.).

Plathypena scabra (Fabricius) primarily feeds on legumes (Pedigo, et al. 1973, J. Econ. Ent. 66: 665-673) as do the only two species of *Colias* that occur in eastern Missouri (see Klots 1960, A Field Guide to the Butterflies of North America East of the Great Plains. Houghton Mifflin Co., Boston. 349 + xvi p.). The low numbers of *Pseudaleitia unipuncta* (Haworth) and *Leucania* sp., which are both grass-feeding caterpillars (Godfrey 1972, U.S.D.A. Tech. Bull. 1450, 265 pp.) suggests a limited amount of grass cover in the areas foraged by the adult Cattle Egrets on the dates sampled.

TABLE 1. Lepidoptera from regurgitated boluses of nestling Cattle Egrets (*Bubulcus ibis*).

Family	Species	Larval Foodplants	Number of Larvae		Number of Adults	
			30 June	7 July	30 June	7 July
Geometridae	<i>Haematopsis grataria</i>	—	—	—	1	1
Noctuidae	<i>Agrotis ipsilon</i>	General feeder	8	12	—	—
	<i>Caenurgina</i> sp. (<i>crassiuscula</i> or <i>erechtea</i>)	Grasses, legumes	1	1	—	—
	<i>Leucania</i> sp.	Grasses	—	1	—	—
	<i>Plathypena scabra</i>	Legumes	1	14	—	—
	<i>Pseudaletia unipuncta</i>	Grasses	—	2	—	—
	<i>Spodoptera ornithogalli</i>	General feeder	—	3	—	—
Pieridae	<i>Colias</i> sp. (<i>eurytheme</i> or <i>philodice</i>)	Legumes	1	—	—	—
Pyralidae	Genus ? species ?	Unknown	1	—	—	—

Caenurgina species have been associated with both grasses and legumes (Crumb 1956, U.S.D.A. Tech. Bull. 1135, 356 pp.). *Spodoptera orinthogalli* (Guenée), a general feeder (Crumb 1929, U.S.D.A. Tech. Bull. 88, 179 pp.), is found frequently on soybeans in the midwestern U.S.A., but not as commonly as *Plathypena scabra* (pers. obs.). The polyphagous *Agrotis ipsilon* (Hufnagel) apparently is associated with moist soil habitats (see Walkden 1950, U.S.D.A. Cir. 849, 52 pp.). *Agrotis ipsilon* also has been reported as a common lepidopteran species in the stomachs of Cattle Egrets shot near Cairo and Simbellaween, Egypt (Kirkpatrick 1925, Egypt Ministry Agr. Tech. Serv. Bull. 56, 28 pp.). This similarity does not suggest that adult Cattle Egrets specifically forage for the larvae of *A. ipsilon*, but does indicate that there might be common denominators in the larval habitat of this noctuid and the foraging habitat of adult Cattle Egrets that could aid investigations of both species.

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Journal of the Lepidopterists' Society
33(3), 1979, 199-200

NEW FOODPLANT RECORDS FOR *EUPHYDRYAS EDITHA* AND *EUPHYDRYAS CHALCEDONA* (NYMPHALIDAE)

On 6 June 1978, I located a small colony of *Euphydryas editha* (Boisduval) near Frenchman's Lake in Plumas Co., California. The colony was at about 7,000 ft elevation, in a dry open meadow transversed by a small semi-permanent creek. The adult butterflies (which were well flown and worn), and particularly females, seemed to be associated with a small yellow plant in the family Scrophulariaceae. A close investigation of this plant, which was later determined to be *Castilleja pilosa* (Wats.) Rydberg, revealed two small tents of first-instar (pre-diapause) larvae. The tents contained a

dozen or so larvae each and they were located near the base of leaves just above the ground. *Euphydryas editha* has been known to feed upon other species of *Castilleja* (e.g., *C. nana* Eastw. and *C. lapidicola* Heller), but not on *C. pilosa* which is a very different looking plant to be a "paintbrush." For a review of the known foodplants of *Euphydryas editha* see White and Singer (1974, J. Lepid. Soc. 28: 103-107).

On 5 June 1978, I was collecting in the Pine Nut Mountains of Douglas Co., Nevada with David L. Bauer. About 11 mi S of U.S. highway 50, on the Brunswick Canyon-Sunrise Pass Road, we discovered a large colony of *Euphydryas chalcedona* (Double-day) on a dry slope (ca. 5,000-6,000 ft in elevation) in the pinyon-juniper zone. This is the first time that a colony of *E. chalcedona* has been located east of the Carson Valley (although Bauer noted that he had taken a few individual specimens in the Pine Nuts previously). The butterflies appear to be assignable to subspecies *macglashanii* (Rivers), but the usual *macglashanii* foodplants (*Penstemon brevifloris* Lindl. and *Penstemon lemmonii* A. Gray) could not be located in the vicinity; nor could we find any other known foodplant of *E. chalcedona*. Adults of both sexes were avidly nectaring at wild onion (*Allium* sp.) and we noticed that females were paying quite a bit of attention to a small *Orthocarpus* sp. with long filamentous leaves. I caged two females with several sprigs of the *Orthocarpus* plant. These females subsequently oviposited on the plants—demonstrating the probability that this is indeed their foodplant. Previously recorded foodplants for *E. chalcedona* have included a number of species of Scrophulariaceae, including *Penstemon*, *Castilleja*, *Mimulus*, *Diplacus* and *Scrophularia* but not *Orthocarpus*. Thus this is the only report of *E. chalcedona* making use of an annual for oviposition. (Is it possible that competition for food between this species and *E. editha*, which frequently feeds on annual scrophs, has occurred in other areas?)

I am indebted to Robert Gustafson of the Los Angeles County Museum of Natural History for identification of the two foodplants. Because the specimens of the *Orthocarpus* sp. were not in flower, they could be identified only to genus and not to species.

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Journal of the Lepidopterists' Society
33(3), 1979, 200-201

NYMPHALIS MILBERTI (NYMPHALIDAE) NEAR SEA LEVEL IN CALIFORNIA

Nymphalis milberti Latreille is regarded as a rarity on the Pacific Coast and is usually recorded at high elevations. Shapiro (1974, J. Res. Lepid. 13: 157-161) pointed out that it is occasionally taken below 300 m in northern and central California and that such occurrences seem to involve only overwintered females. It was suggested that *N. milberti* overwinters at low elevations and breeds there in April, the resulting offspring dispersing upslope. Because of the low numbers, such movements would be very difficult to detect. *N. milberti*, unlike *N. californica* Bdv., is not considered a migratory species. Its suggested movements, however, parallel those proposed by Shapiro (1975, J. Res. Lepid. 14: 93-97) for *N. californica*. In the northeast *N. j-album* Bdv. & LeC. shows a seasonal pattern of occurrence suggesting the same phenomenon (fresh adults at high elevations in July; overwintered ones at low elevations November-April; Shapiro 1974, Search (Agriculture) 4(3): 12).

On 2 April 1978 Mr. Noel LaDue took a worn female *N. milberti* at Rancho Cordova, Sacramento Co., California (about 20 m). On 26 May 1978 I took two fresh male *N. milberti* on vetch flowers about 1.5 km from the site of LaDue's capture. Both native and introduced stinging nettles (potential host plants) occur in the vicinity in riparian forest. The implication that breeding took place is clear and is bolstered by a report

(J. Brock, *in litt.*) of early spring breeding near Bakersfield in the San Joaquin Valley (in another year). It is worth noting that populations of *N. milberti* were unusually high in the Sierra Nevada (Nevada, Sierra counties) and the Trinity Alps (Trinity Co.) in late 1977. On 16 August 1977 several dozen fresh individuals were observed on *Monardella* flowers on the south slope of Mount Shasta, 1,425 m. If enough low-elevation records can be accumulated it may be possible to demonstrate regular altitudinal dispersal even in a species so rare that tagging is unlikely to bring significant results.

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Journal of the Lepidopterists' Society
33(3), 1979, 201-203

HISTORIS ODIUS (NYMPHALIDAE) SUCKING ON COCOA SEEDS (STERCULIACEAE) IN NORTHEASTERN COSTA RICA

Although many genera of the subfamily Nymphalinae in the American tropics suck juices from dung, rotting fruit, and sap flows on trees (e.g., Seitz 1924, *Macrolepidoptera of the World*, Vol. 5, American Rhopalocera, A. Kernan Verlag, Stuttgart, 615 pp.; Gilbert 1972, *Proc. Natl. Acad. Sci. USA*, 69: 1403-1407), among the best known for such behavior are *Historis* and *Prepona*. *Historis odius* Fabricius is a large, robust, and swift-moving species widespread throughout the West Indies, Mexico, and Central and South America (Seitz, *op. cit.*). Although a familiar species in forest light gaps and borders in tropical rain forest regions generally below 600 m elevation (*pers. obs.*), *H. odius* adult food records are scarce. From the available literature, one must assume that they feed on rotting fruit, fermenting sap, and dung. While this is very likely the case, I wish to report *H. odius* sucking on the drying seeds of the well known commercially-cultivated, tropical cash crop, *Theobroma cacao* Linnaeus (Sterculiaceae) commonly known as "cacao" or "cocoa."

The farm complex Compañia Agrícola Hüntro S.A. (CAHSA) includes extensive plantings of cacao. During the latter part of the wet season each year, large quantities of seeds are extracted from pods and placed on drying tables. Before being shipped, the seeds must be dried. In sunny weather this process usually takes 2-3 days, with 4-7 h exposure each day. When extracted from the pods and placed on the drying tables, the 30-40 mm long ovoid seeds are individually encased in a white pulp which is known to be sweet, highly aromatic, and palatable to mammals, which act as dispersal agents (Cuatrecasas 1964, *Contribut. U.S. Nat. Herbarium*, 35: 379-614), even though the seeds are scentless and tasteless to humans. These properties of the pulp apparently attract small mammals which remove the seeds, suck the pulp, and disperse the seeds (*ibid.*). Little is known about invertebrates being attracted to the seeds and pulp. Between 30 July and 2 August 1978, I had the opportunity to observe *H. odius* and other insects visiting the freshly extracted and drying seeds (with pulp intact) at "Finca La Tirimbina," a part of the CAHSA complex near La Virgen (220 m elev.), Heredia Province, Costa Rica. Although the weather is generally rainy and overcast at this time of the year, the three days of observation were clear and sunny.

At 1100 h 30 July, I noticed three individuals of *H. odius* sucking on the sticky, moist surfaces of the drying seeds; all of the butterflies were on the same drying table (about 4 × 5 m) and each had its proboscis wedged down between the seeds (Fig. 1). This table was shaded under a roof, and other tables in direct sunlight and containing seeds which had been drying for longer periods had attracted no butterflies or other insects. Other insects seen on the shaded table included one freshly eclosed *Hamadryas februa*



FIG. 1. *Historis odius* sucking on the moist pulp of cacao seeds on a drying table at "Finca La Tirimbina," La Virgen, Heredia Province, Costa Rica (30 July 1978, 1130 h).

(Nymphalinae) and many *Trigona* bees (entirely black species). Intermittently throughout this day and the next one, I noticed that the *H. odius* adults were present, usually 1–3 at any one time. One adult was very tattered while the other two appeared freshly eclosed. The latter were extremely wary and would take flight at the slightest disturbance, while the tattered individual was more sedentary and could be photographed. Typically when disturbed, an adult would fly off and perch on a nearby fence or roof top, only to return to the seeds within 5–20 min. Although all three adults perched on the seeds within a meter of each other, there were no interactions (aggressive or otherwise) among them. Because of its distinctive and easily recognizable wind damage, the tattered butterfly seen over a two-day period was assumed to be the same individual; possibly the same is true for the two fresh adults. By the third day, the seeds were very dry and the butterflies (and the other insects) ceased to visit them. On the first day of observation, the seeds were placed on the table by 0800 and had been drying only a few hours when the butterflies first appeared. During the first day, one fresh male of *Morpho peleides* fluttered around the seeds. As my observation periods were inconsistent, it is not known how many other butterflies exhibited an interest in the seeds. It was clear that *H. odius* was feeding on the moist pulp around the seeds. The drying seeds were highly aromatic to me and to others in the area, presumably the result of a fermentation process brought on by the drying process.

Owing to the relative inaccessibility of these seeds under natural conditions (encased in a tough pod or pulp quickly eaten by vertebrates), the pulp is probably not a major food source. *Historis odius* and other nymphalines exploit a broad range of rotting organic substrates in lowland tropical rain forests of Central America. While these observations occurred during the wet season, *H. odius* is active throughout the year in this region since two fresh adults were captured during February and April (1970) at nearby "Finca La Selva." Different tribes within the Nymphalinae contain genera that feed on rotting fruit and tree sap (Howe 1975, *The Butterflies of North America*, New

York: Doubleday & Co., 633 pp.) and these insects obtain nitrogenous compounds and other substances that may increase various parameters of reproductive effort or adult longevity (Gilbert 1972, op. cit.). The timing of visits by the butterflies to the drying seeds is a behavioral response to products of decay in the pulp. This is a time when the seeds are highly aromatic but not in the sense traditionally maintained since no vertebrates appeared at them on the drying tables.

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Journal of the Lepidopterists' Society
33(3), 1979, 203-204

NEW OVIPOSITION PLANT FOR *EUPHYDRYAS PHAETON* (NYMPHALIDAE)

Larvae of the checkerspot *Euphydryas phaeton* Drury feed on several species of Scrophulariaceae and a few other species such as *Plantago* sp. (Tietz 1972, An index to the described life histories, early stages and hosts of the Macrolepidoptera of the continental United States and Canada, vol. 1, Allyn, Sarasota, Florida). However, female *E. phaeton* have only been reported depositing eggs on turtlehead (*Chelone* sp.: Scrophulariaceae) (Edwards 1884, Butterflies of North America, vol. 2, Houghton Mifflin, Boston; Tietz, op. cit.). Here I report oviposition by *E. phaeton* on English plantain (*Plantago lanceolata* L.).

I observed four females depositing clusters of eggs on English plantain in an old field in Manlius, New York on 12-13 July 1978. Twenty-nine egg clusters were collected on plantain: six occurred on two large plants which were touching at the bases, two were found on the same plant, two others occurred on the same leaf, and the rest were found singly on plants. Nine of these were on the top side of the leaves rather than on the under surface. The mean number of eggs in these clusters was 278.7 (range 115 to 516) which was not significantly different from clusters deposited on turtlehead (*C. glabra* L.), a larger and broader-leaved plant than plantain ($t = 0.00045$, $P > 0.50$, $df = 58$) (Stamp, unpubl. data). I spent a total of 6 afternoon hours following females ($n = 7$) for periods of 20 to 105 min. All of these females exhibited plant search behavior for oviposition sites (going quickly from plant to plant), but only two females performed leaf search behavior (searching plant and touching leaf with tip of abdomen). This second behavior occurred only on plantain and the first time these females encountered it during the observation period. The females in this field spent much more time exhibiting plant search behavior than females observed in areas with turtlehead (Stamp, unpubl. data). This probably reflects some major differences between the two host plants. Turtlehead grows 2-4 ft in height, may occur in large, dense patches (diameter several ft across) and leaves of the plants frequently are touching. In contrast, plantain is a small plant (height of leaves less than 1 ft), is not common in this field, and occurs in small patches with plants generally not touching each other. A second population of *E. phaeton* in a bog near McLean, New York was also using English plantain for oviposition sites. Neither of these areas had turtlehead.

The field in Manlius supported a large number of *E. phaeton*. Using mark-and-recapture methods and Bailey's modification of the Lincoln index (Ehrlich and Davidson 1960, J. Lepid. Soc. 14: 227-229; Poole 1974, An Introduction to Quantitative Ecology, McGraw-Hill, New York), I estimated 292 adults during this period (peak of flight season). This was probably only a third of the colony at that time as two adjacent areas also had *E. phaeton* and *P. lanceolata*. One of these areas was a first-year old field in

which plantain was larger and more common than in the other areas, but it had fewer adult *E. phaeton* and only one egg cluster was found there.

It is not surprising that *E. phaeton* uses *P. lanceolata* as *Euphydryas* species in the western United States use *Plantago* species for oviposition sites. But it does raise an interesting question: why aren't there more *E. phaeton*, especially in old fields, if they will deposit eggs on such a common plant as English plantain?

I am especially grateful to John Kemper for assisting with the field work. I thank Edward Jennejohn for showing us the Manlius and McLean populations. This research was supported by funds from the Univ. of Maryland Chapter of Sigma Xi.

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Journal of the Lepidopterists' Society
33(3), 1979, 204

PRIOR NAME FOR A PETROVA PINE MOTH (TORTRICIDAE)

Not long after describing *Petrova khasiensis* (Olethreutinae), a moth developing on pine in northeastern India, I chanced to see two specimens similar to it at the U.S. National Museum of Natural History identified as *Eucosma argyrocyama* Meyrick. Subsequent comparison of pertinent specimens, including male genitalia, confirmed that the former name is indeed a synonym of the latter. Moreover, both names were based on specimens from the same locality, the town of Shillong. The findings are summarized below.

***Petrova argyrocyama* Meyrick, new combination**

Eucosma argyrocyama Meyrick 1921, Exot. Microlepidop. 2: 447; Clarke, 1958, Cat.

Type Spec. Microlepidop. Brit. Mus. (Nat. Hist.) Descr. Edward Meyrick 3: 347.
Petrova khasiensis Miller 1977, J. Lepid. Soc. 31: 135, New Synonymy.

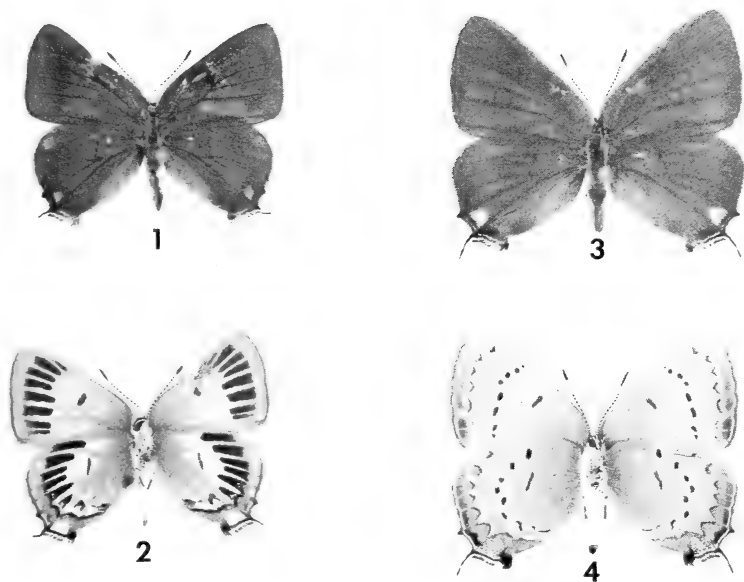
Specimens compared included one of the above *Petrova argyrocyama* (Shillong . . . , 5,000 ft 5.28 TBF, Comp. with type . . . Det. J. F. G. C. . . . , ♂ genit. slide MAM 1115781) and the *P. khasiensis* ♂ holotype. Wing and genitalia illustrations of authentically determined representatives may be seen in the works by Clarke and Miller cited above.

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Journal of the Lepidopterists' Society
33(3), 1979, 204-205

ABERRANT SATYRIUM A. ACADICA (LYCAENIDAE)

On 4 July 1978 a recently emerged aberrant male *Satyrrium acadica acadica* (Edwards) was captured at Elgin, Kane Co., Illinois. This species is fairly common in the Chicagoland region wherever the hostplant willow (*Salix*) grows. The specimen was collected along a small creek within the city limits of Elgin while it rested on a leaf of a willow sapling.



FIGS. 1-4. Specimens of *Satyrium a. acadica* from Illinois. 1 and 2, aberrant specimen, dorsal and ventral views, respectively; 3 and 4, same, for a normal specimen, showing the typical markings of this species.

Figs. 1-4 show the dorsal and ventral views of both the aberrant specimen and a normal specimen. The most striking difference between them is that in the aberrant specimen the normal ventral postmedian rows of spots and submarginal "V" markings are replaced by large rectangular bars extending from the submarginal area into the postmedian area on both primaries and secondaries. I wish to express my thanks and appreciation to Dr. Clifford D. Ferris, University of Wyoming, Laramie for making the photographs of the specimens used in this article.

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BOOK REVIEW

GOZMÁNY, L. 1978. LECITHOCERIDAE. In Amsel, Gregor & Reisser, *Microlepidoptera Palaearctica*, v. 5: text, 306 pp., 168 text figs.; plates, 122 (unnumbered) pp., 15 full color plates, 93 black and white. Vienna. Price of two bound, gold imprinted parts, DM540,—(approximately \$290.00 U.S.); subscription price, DM450,—.

The new volume of this monumental series fills the reader with admiration: one holds his breath an instant and wonders that such a beautiful book can be produced in this day and age.

The series "*Microlepidoptera Palaearctica*" is so well known by now that my statement that the fifth volume has been written in the same spirit and style, and that it has been produced at the same high standards as the previous four, characterizes its qualities adequately. So much well-merited praise already has been given to the series, that it is difficult to add more, without being repetitious. Still, the present volume earns a special qualification: among those families of *Lepidoptera* already treated, the *Lecithoceridae* are, without doubt, the least known—and as a separate family, they are hardly known at all! Amazingly, Dr. Gozmány's critical revision provides access to a new group of *Lepidoptera* in the Palearctic fauna. Therefore, the scientific value of the fifth volume is considerable.

In the Introduction, an historical survey of the *Lecithoceridae* is presented. This group was separated as late as 1947 by Le Marchand as a Palearctic subfamily of the *Gelechiidae*, and in 1955 it was described again by Clarke as a separate family (the *Timyridae*), which included numerous species of the Oriental and Ethiopian tropics. Now for the first time the limits of the group are defined and a generic key to the Old World fauna is given as a basis for its total revision. (The family does not occur in the New World.) A list of all of the literature on the Palearctic species is compiled and each species has its own list of citations. Dr. Gozmány was able to study and dissect all of the type specimens except a very few which could not be found. The limits of the geographic region have been extended so that several neighboring countries are included in it [e.g., Nepal, Assam, North Burma and even Formosa (Taiwan)], in order to incorporate potential future intruding species. This has been done in view of our still inadequate knowledge of the family. Hardly anything is now known concerning the early stages and ecology of these insects, except in the case of several common European species. The *Lecithoceridae* seem to be chiefly detritophagous, but they also consume withering and dead plant tissue. Adults are attracted to light. The family is now divided into two subfamilies, with a total of 41 genera and 168 species. Of these, 15 genera and 67 species are new. Each is illustrated in full color with black-and-white figures of the genitalia of both sexes. In the second part there are 15 plates of magnificent watercolors by Dr. Gregor, and additional sketches and genitalia drawings by the author.

An important novelty is that the description of every species is followed by a special paragraph, summing up the differences between it and other allied species. Species discrimination is therefore made possible through keys, diagnoses, color and black-and-white figures, as well as by these handy summaries—methods worth following in the future.

With regard to benevolent critical remarks, I have just one: obviously the diagnoses of the species are meant to be more or less complementary to the color illustrations (or the other way around); together they are excellent, but separately the diagnoses are too concise. Perhaps this is a question of taste, but I would have preferred a diagnosis complete in every detail, as a taxonomic documentation for the identification of each species.

Entomologists have a strong personal attraction to certain groups of insects. This is one thing which makes our science so very fascinating! I must confess that I enjoy such a feeling of involvement with the *Lecithoceridae*, as well as with certain other groups. I have been highly privileged to encounter these elegant insects in numbers in southern Asia. This is one more reason that I must congratulate the author, artist, and editor

for their achievements. I welcome the present revision warmly and recommend its subject to a wide circle of my colleagues interested in Lepidoptera.

Unusual additions to this fifth volume are the sympathetic obituary of the third Editor of the series, the late Hans Reisser, and a fascinating review of the origin of the ten-year-old series "Microlepidoptera Palaearctica," by its initiator and Editor-in-Chief, Dr. H. G. Amsel.

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Journal of the Lepidopterists' Society

33(3), 1979, 207-208

BOOK REVIEW

ESSAI DE CLASSIFICATION DES LÉPIDOPTÈRES PRODUCTEURS DE SOIE. Original fascicles published 1897-1934 in *Compte rendu des Travaux du Laboratoire d'Études de la Soie*, Lyon. Facsimile reprints now available, published 1976-1978 by Sciences Nat, 2 rue André Mellenne, Venette, 60200 Compiègne, France. Price different for each fascicle, but varying from 42 FF to 99 FF each. Presently only available through Sciences Nat.

This old classical series on Saturniidae (= Attacidae) and related moths has been quite rare and unavailable to workers. The series is particularly useful to taxonomists and of special interest to amateur students of Saturniidae. I own an original copy of fasc. 2 and can thus see that these reprints are accurate reproductions of the originals, except for size: originals measure ca. 19×27 cm and reprints are ca. 15×22 cm. It is now possible for both libraries and individual lepidopterists to own copies of these important works.

The series resulted from the immense interest in these moths from their economic standpoint as silk producers. Several experts at the Silk Laboratory in Lyon authored the text, in French. The figures are not colored, but are line drawings and some are done from photographs. Almost every species is figured in the adult stage and a few larvae and cocoons are depicted. Citations to original descriptions and lists of synonymies precede the text of each taxon. The text mainly describes the imago and gives the patria. Each fascicle is indexed. The pagination coincides with that of the original separates (*extraits*) which differs from that in the *Compte rendu . . . Soie*. Below is a synopsis of each fascicle:

Fascicle 1. 1897. By J. Dusuzeau & L. Sonthonnax. Introductory chapter discussing morphology and early classification of Lepidoptera. Taxonomic group covered is Saturniidae, Saturniinae, Tribe Attacini: genera *Callosamia*, *Samia* (= *Philosamia*), *Hyalophora*, *Epiphora*, *Attacus*, *Rothschildia*, and *Archaeoattacus*. Most species figured well. 52 pages.

Fascicle 2. 1899. By L. Sonthonnax. The genus *Coscinocera* (Tribe Attacini) which had been omitted from fasc. 1 is covered here. The tailed saturniids are covered, including the complex of genera related to *Saturnia/Eudia*; also Agliinae, *Argema*, *Graellsia*, *Eudaemonia* (= *Copiopteryx*), *Eustera* (African). Also included are *Copaxa* and *Antheraea*. Many cocoons and a few larvae are figured. 78 pages.

Fascicle 3. 1901. By L. Sonthonnax. Excepting the Indo-Australian *Syntherata* and Neotropical *Sagana*, all of the species discussed and figured in this fascicle (such as *Nudaurelia* and *Imbrasia*) belong to the large African tribe Bunaeini. 76 pages.

Fascicle 4. 1904. By L. Sonthonnax. A wide range of saturniid groups are

covered, including the complex of genera related to *Saturnia/Eudia*; also Agliinae, Salassinae, more Bunaeini, most Arsenurinae, *Polythysana* (Hemileucinae), and *Cercophana* (Cercophanidae). 86 pages.

Fascicle 5. 1906. By A. Conte. The coverage here is of the large genus *Automeris* and its allies, plus a few Nearctic and Mexican *Hemileuca*. The figures are quite poor in this fascicle, not having reproduced well. 121 pages.

Fascicle 6. 1908. By A. Conte. The only saturniid genus included is the African *Cyrtogone*. Numerous other moths from around the world including many families, mostly Bombycoidea, are covered. Genera include *Borocera*, *Gonometa*, *Pinara*, and *Taragama*. Judging from the lists of synonymies, the literature on many of these species was scant. 73 pages.

Fascicle 7. 1911. By A. Conte. More non-Saturniidae, as in fasc. 6. *Bombyx mori* L. and its relatives, Brahmaeidae, *Epia*, *Ocinara*, *Synadia*, *Theophila*, *Therina*, *Endromis*, etc. are figured and discussed. 90 pages.

Fascicle 8. 1918. By A. Conte. Supplement to previous fascicles. Text and figures of over 30 species and subspecies described since publication of the earlier fascicles. 42 pages.

Fascicle 9. 1931. By E.-L. Bouvier & P. Riel. Contains a catalogue of Saturniidae and a list of specimens (and their data) in the collection of the Laboratory of the Study of Silk. Also a treatise by P. Bonnet on *Nephila madagascariensis* Vins., the great silk-producing spider. Next a chapter on diseases of silkworms by A. Paillot. Lastly, a chapter on artificial textiles and their chemical and physical properties by D. Levrat. 141 pages.

Fascicle 10. 1934. By P. Riel. A small second supplement giving text and figures of 16 Old World Saturniidae. 16 pages.

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Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, $8\frac{1}{2} \times 11$ inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 p.

——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. *Adv. Genet.* 10: 165–216.

In the case of general notes, references should be given in the text as, Sheppard (1961, *Adv. Genet.* 10: 165–216) or (Sheppard 1961, *Sym. R. Entomol. Soc. London* 1: 23–30).

Illustrations: All photographs and drawings should be mounted on stiff, *white* backing, arranged in the desired format, allowing (with particular regard to lettering) for reduction to their final width (usually $4\frac{1}{2}$ inches). Illustrations larger than $8\frac{1}{2} \times 11$ inches are not acceptable and should be reduced photographically to that size or smaller. The author's name, figure numbers as cited in the text, and an indication of the article's title should be printed *on the back* of each mounted plate. Figures, both line drawings and halftones (photographs), should be numbered consecutively in Arabic numerals. The term "plate" should not be employed. *Figure legends* must be typewritten, double-spaced, *on a separate sheet* (not attached to the illustrations), headed EXPLANATION OF FIGURES, with a separate paragraph devoted to each page of illustrations.

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JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



29 October 1979

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The Lepidopterists' Society is a non-profit, scientific organization. The known office of publication is 1041 New Hampshire St., Lawrence, Kansas 66044. Second class postage paid at Lawrence, Kansas, U.S.A. 66044.

Cover illustration: Third instar larva of *Limenitis archippus* Cramer (Nymphalidae) preparing to enter winter diapause. The larva is resting on the lip of its hibernaculum constructed from the basal portion of a chewed tubular willow leaf (*Salix babylonica* Linnaeus) covered with silk. In the autumn such larvae begin facultative diapause in response to decreasing day-length. Original drawing by Mr. George C. Ford, Jr., Graphics Illustrator, Department of Biological Sciences, University of Maryland Baltimore County, 5401 Wilkens Avenue, Catonsville, Maryland 21228.

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Supplement to Volume 33

Journal of the Lepidopterists' Society
Supplement to Volume 33

ANNOTATED LIST OF LARVAL FOODPLANT RECORDS FOR 280 SPECIES OF AUSTRALIAN MOTHS¹

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ABSTRACT

Many new and specific larval foodplant records are listed for 280 spp. of Australian moths, of which 13 are Microlepidoptera and 267 are Macrolepidoptera; 2 additional records (1 agaristid, 1 arctiid) are Fijian. Twenty-two families are represented, as follows: Agaristidae (8 spp.); Anthelidae (12); Arctiidae, s.l. (11); Carthaeidae (1); Cochyliidae (1); Cossidae (1); Geometridae, s.l. (155 spp. or 55% of the total); Immidae (1); Lasiocampidae (9); Limacodidae (5); Lymantriidae (4); Noctuidae (25); Nolidae (10); Notodontidae, s.s. (8); Oecophoridae (3); Pterophoridae (1); Pyralidae (2); Saturniidae (1); Sphingidae (4); Thaumetopoeidae (11); Xyloryctidae (4); Zygaenidae (5). Representation of Australian States (encompassing all listed localities where foodplant records are involved) is as follows: South Australia (68%); Western Australia (17%); northeastern Queensland (9%); New South Wales, Northern Territory, and western Victoria combined (6%); Tasmania (none). The majority of S. Aust. records are from the vicinity of Adelaide (Blackwood-Belair district) and most of the W. Aust. records are from the Geraldton district. Scientific names and families are given for all plants, with complete author citations and sources of determinations for each. A foodplant index lists most plants by common, generic, and specific names. All moths are arranged alphabetically in the text, with cross-references to some generic synonyms. Additional details are given for many spp., usually including: (1) code-numbers by which all preserved material can be located in various named institutions; (2) details on the stages preserved and photographs made for each life history; (3) dates of adult emergence and of larval occurrence on the plants; (4) part(s) of the plants eaten; and (5) remarks on distinctive features of larvae or adults in species that are difficult to separate.

¹ NOTE: The author regrets that he will not be able to supply reprints of *this paper*, and that reprints of McFarland (1972a-1975) are no longer available. *This paper* is available separately as a back issue of the *Journal of the Lepidopterists' Society*.—Ed.

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ANNOTATED LIST OF LARVAL FOODPLANT RECORDS FOR 280 SPECIES OF AUSTRALIAN MOTHS

INTRODUCTION

This annotated list summarizes certain information about the adults, early stages, and foodplants of Australian moths I have reared and studied over the last 14 years (1 December 1964–30 November 1978). Many of the species here listed have been reared from eggs which were obtained from confined females. For most details of the rearing and preservation techniques used, see earlier papers (McFarland, 1964; 1965; 1972a; 1973). Few (if any) of these specific foodplant records have ever been published before, and a high percentage of these life histories were previously unknown. This work is documented by an abundance of preserved material (all stages), plus extensive notes and numerous photographs of the living adults, eggs, larvae, and pupae.

More than half of the foodplant records in this paper involve the family Geometridae, s.l. (155 spp. or 55% of the total reported here). The geometrid subfamilies are represented as follows: Ennominae (72 spp.), Geometrinae (37), Larentiinae (16), Oenochrominae (24), Sterrhinae (6). Among the other "macro" families, numbers of spp. reported in the list are: Agaristidae (8), Anthelidae (12), Arctiidae, s.l. (11), Carthaeidae (1), Lasiocampidae (9), Limacodidae (5), Lymantriidae (4), Noctuidae (25), Nolidae (10), Notodontidae, s.s. (8), Saturniidae (1), Sphingidae (4), Thaumetopoeidae (11), and Zygaenidae (5). Foodplant records are also included for 13 miscellaneous "micros": Cochylidae (1), Cossidae (1), Immidae (1), Oecophoridae (3), Pterophoridae (1), Pyralidae (2), and Xyloryctidae (4). A number of other foodplant records had to be omitted due to uncertainty concerning the specific

EDITOR'S NOTE—This issue constitutes a Special Supplement to Volume 33 of the *Journal of the Lepidopterists' Society*. Funds to partly cover publication costs were specially voted by the Executive Council of the Society at the July, 1978 meeting in Louisville, Kentucky. The present editors wish to acknowledge the able assistance of Dr. G. L. Godfrey of the Illinois Natural History Survey, Urbana, Illinois, who has given generously of both his time and expertise in preparing this manuscript for the publisher. His cooperation is greatly appreciated by both the author and the editors.

identities of some of the moths, although a few of these have been included if the larvae (or the foodplants) were of particular interest.

This paper was written as foundational to a series of illustrated life history publications that are intended to follow in the future. However, this basic information on foodplants and seasonal occurrences is being reported in view of the man-caused destruction of habitat that is rapidly spreading through the hills south of Adelaide where most of the listed species occur. Eventually, all that will remain of the native vegetation near Adelaide will be the larger trees and shrubs, with most of the smaller native plants gone; this, in fact, nearly describes the present situation.

Representatives of all South Australian (S. AUST.) specimens discussed here (material collected between Jan. 1965–May 1970) have been deposited in the South Australian Museum of Natural History (Entomology Department), North Terrace, Adelaide. Other specimens from Western Australia, and some duplicates from S. Aust., have been deposited in: the British Museum (Natural History), London; the Australian National Insect Collection (A.N.I.C.), Canberra; the Western Australian Department of Agriculture (Entomology Section), Jarrah Rd., South Perth. Most of the Queensland material (1972) has been given to the A.N.I.C. Some of the geometrid larvae are temporarily being retained by the author for study, but all will eventually be deposited in one or more of the above named institutions. All of the original photographs (prints and negatives), and the handwritten notes, plus a complete duplicate set of the notes (photocopied and stored separately in a bank vault) are at present being held by the author. Other photocopied sets of the same notes will eventually be distributed to one or more of the above institutions. A complete *index* to the collection is also kept up-to-date (in notebook form), all species being listed in numerical order by family and code-number; duplicate copies of this index (complete only through 1970) have been deposited at the S. Aust. Natural History Museum (Adelaide); with D. S. Fletcher at the British Museum (N.H.) (London); at the Los Angeles County Museum of Natural History (California); and with T. C. Emmel of the Zoology Department, University of Florida (Gainesville). This index also covers the North American life history material in my former U.S. collection (through October 1964), for which the majority of larval foodplant records were recently published (McFarland, 1975); this material is in the Los Angeles County Museum of Natural History.

All specimens in vials have been fixed in K.A.S.A. (see McFarland, 1965) or K.A.A. (3-2-10), and preserved in 80% to 90% ethyl alcohol. (Ideally, the concentration of alcohol for permanent storage should be around \pm 80%; if much lower than 75%, collapse or darkening of speci-

mens will sometimes occur, but if much over 85%, setae often become too brittle and easily broken. A little glycerine added to the alcohol may be helpful.)

All reared **parasites** associated with these moths have been preserved and deposited in the following three institutions: Diptera mostly in the A.N.I.C. (Canberra) and the B.M. (N.H.) (London); Hymenoptera mostly in the W. Aust. Department of Agriculture, Entomology Section (South Perth). Of the ± 40 tachinid spp. reared to date, many have been determined, at least to genus, by D. H. Colles (Canberra) or R. W. Crosskey (London), but none of the hymenopterous parasites (± 60 spp.) have been identified as yet. All parasites have been code-numbered, and the details were recorded in two separate series of notes (D and H); empty puparia and cocoons have always been saved when possible. It is worth noting that there seems to be a great preponderance of hymenopterous over dipterous parasites associated with the geometrids (and especially the Geometrinae), whereas, in most of the field-collected larvae representing other families of Lepidoptera, dipterous parasites were much more frequently encountered. This may have been a coincidence, of course, but it might reflect the natural situation correctly.

Life History Stages Preserved: At the end of each entry (in parentheses) certain numbers designate exactly which stages of that life history have actually been preserved and/or photographed. In order to save considerable space, this information is conveyed simply by use of the following numbers:

- 1 = **Adults** (for photos this usually implies living individuals in their natural resting positions; sometimes also spread specimens).
- 2 = **Eggs** (preserved material can be alcoholic and/or dried unhatched eggs, or dry empty shells, as described in an earlier paper (McFarland, 1972a: 209-211)).
- 3 = **First instar larvae** (specifically).
- 4 = All or some **intermediate instars** (second through penultimate).
- 5 = **Last instar** (specifically); in notebooks and on all labels this has been abbreviated as "L5," regardless of actual number of instars involved.
- 6 = **Pupae** (in alcohol, or empty dry shells inside gelatin capsules, on the pins beneath reared adults; often *both* wet and dry are saved).
- 7 = **Cocoons** or **soil-cells** (also occasionally implies larval nests or examples of feeding-damage to the foodplant, if unusual or distinctive in some respect). Dry frass samples from last instar larvae of some spp. were also preserved but have not been mentioned.
- 8 = **Parasites** reared and preserved: d = Diptera; h = Hymenoptera; m = mites or miscellaneous. (Examples: "8dh" would indicate one species of Diptera and one species of Hymenoptera reared from the same host; "8hhh" would indicate 3 different hymenopterous parasites from the same host species.)
- 9 = **Notes** were made (nearly always including color descriptions based on living specimens; often details on cryptic coloration, habits, and behavior; also food-plant and habitat descriptions, etc.).

With reference to **photographs**, the number followed by "c" implies 35 mm color slides (otherwise they are 35 mm black & white). Numerous habitat photographs were taken between 1966–1970, depicting my main collecting localities as they were at that time. These are kept in the same files with the life history photographs. Taxonomists having queries on any of this material are welcome to write me; I would be able to provide further details in many cases.

Specimen Code-numbers: A consistent code-numbering system is vital to this type of work. It is not always possible to quickly identify reared moths with accuracy (particularly in remote or poorly-known regions!), and a percentage usually prove to be new species. The use of code-numbers guarantees that, as long as specimens or photographs from my original series exist somewhere, they can always be re-checked by future workers; these published records will therefore remain essentially identifiable whether or not subsequent taxonomic revisions cause changes in the nomenclature, which they certainly must in some cases.

The ennomine geometrid genus *Chlenias* is a good example: Few of these relatively similar-looking but variable adults can at present be easily separated with accuracy, yet the larval differences (in coloration, maculation, morphology, habits, behavior, and foodplant preferences) are often consistent and striking, and provide useful taxonomic clues. The biological and phenological information here reported for *Chlenias* spp. took me years to gather and sort out. It would be ridiculous to exclude the unidentified (but obviously different) *Chlenias* spp. from this report merely for lack of specific names! Future investigators of the *Chlenias* complex will be off to a rapid head start if they have access to this information and the associated preserved material. The same situation also applies to the 4 very distinctive but unidentified *Pterolocera* larvae (Anthelidae). Code-numbering effectively overcomes the urgency of immediate naming by providing simple "interim handles" for all taxa studied. Determinations can follow years later, as convenient (or when possible).

All of the rearings, whether from eggs (ex confined ♀♀) or field-collected larvae, are code-numbered for separation by family and species. For example, "G.80" refers only to the oenochromine geometrid (G.), *Phallaria ophiusaria* Gn. (80), and not to any other moth. A capitalized letter (A, B or C, etc.) directly following any code-number implies material from another population of the same species. The code-numbers are enclosed inside all vials containing preserved immatures, and the identical numbers are handwritten on blue labels attached to the corresponding pinned adults. They are also enclosed with all preserved dry egg shells, frass samples, occasional cocoons, and associated parasites

reared from field-collected larvae. Field notes and related photographs are also identically code-numbered to cross-reference them to the alcoholic and/or dry material they represent. In the list that follows, my code-numbers usually appear in the first line of each entry (after the determination citation) where applicable; some (few) species were not code-numbered, usually in those instances where no notes were written.

Dates: The usual or "normal" dates of larval and adult occurrence (in the localities named) are given, if known with certainty, including peaks of abundance when these were obvious. All dates applicable to adults include the entire flight period, from the earliest to the latest recorded for each species during the study period. All dates given refer only to the localities named; they are not intended to imply knowledge of flight times (or larval occurrence) in any other districts. If the adults came to light only or primarily after midnight (\pm 0130-0400 hrs), a remark to this effect has been inserted after the months of flight; this applies to many of the moths studied, even including some winter-emerging species that fly on cold nights. The ennomine geometrid, *Smyriodes aplectaria* (G.140), is an example of the latter.

The months are subdivided simply as follows: "early" = 1st through 10th; "mid" = 11th through 20th; "late" = 21st through 31st. (Finer subdivisions of the months become meaningless over a period of several consecutive years in view of the usual local climatic fluctuations from year to year.) Dates showing months only (minus the year) usually imply that I have multiple records for that species over several years, but if the year is also included this usually implies only a single record.

Some (relatively few) of the spring- and summer-emerging moths have more than one generation per year, whereas the great majority of autumn- and/or winter-emerging moths are single-brooded, with the larval stage often extending over two, three, or even more months during the coldest and wettest part of the year in southern Australia (\pm May-Aug. or Sept.).

Larvae may be presumed diurnal feeders (or feeding both day and night) unless it is stated otherwise; where included, such information refers only to final instar larvae. (Some species that feed both day and night when small become strictly nocturnal feeders in later instars, and their habits or behavior may also change in other ways.) This distinction, in the case of strictly nocturnal feeders, can be of great importance when hunting such larvae in the field. Entirely different searching and collecting techniques are obviously required for larvae inclined to hide by day under loose bark, well down the stems of their foodplants, or under debris beneath the plant, often far-removed from their places of nocturnal feeding.

Abundance-ratings: After "*Adults*" (in parentheses) a capital letter, indicating the relative abundance, is given for those species with which I was more familiar. In the case of Blackwood, this information is based on numbers of adults attracted to two ultraviolet lights ("black light"—G.E. F15T8.BL), situated in the same positions during nearly six consecutive years of resident collecting in the same suburban garden, between January 1965 and September 1970. All hours from dusk to dawn were regularly sampled, during all seasons of the year, throughout this period.

These abundance-ratings are expressed as follows: (A+) = *extremely abundant*; (A) = *abundant*; (B+) = of *moderate* abundance but tending toward (A); (B) = of *moderate* abundance, not really common but by no means rare; (B-) = of *moderate* abundance but tending toward (C); (C) = *rare*, with ± 6 or fewer individuals seen in most years; (D) = *very rare*, with only 2 or fewer individuals seen in most years (some years none). These abundance-ratings refer only to the occurrence of adult moths (at uv. lights), in the specific localities named, and they also attempt to reflect the "average" or overall relative abundance of cyclic species during the entire study period. (As in all localities, some South Australian species fluctuate considerably, whereas others appear to remain relatively constant in their numbers from year to year.)

The foothills S. of Adelaide are in the path of rapidly expanding destruction from mushrooming suburbia (euphemistically known as "development"). It can be predicted that changes undoubtedly will take place in the relative abundance of some of the moths named in the pages that follow (particularly those restricted to feeding on genera other than the dominant *Eucalyptus* or *Acacia*), as the few remaining vestiges of "original" habitat disappear around Blackwood, Belair, and elsewhere in the Mt. Lofty Range. Some of these moths, whose foodplants are already scarce, may even become extinct in the Blackwood district, or will inevitably become less abundant than they were in former years. It is therefore important to keep in mind that most of the observations here reported were made between 1965–1970.

Localities: Most of these notes were recorded in the Mount Lofty Range, at 2 Gulfview Rd., Blackwood (elevation 800–900 ft.), a hilly suburban area about 7 road-miles south of Adelaide, South Australia. The Blackwood observations were centered almost entirely in and around the Gulfview Rd. — Hannaford Rd. area. Periodic visits (in all seasons) were also made to a small but rich and varied remnant patch of nearly undisturbed native flora inside the northwest section of Belair National Park, about 2 mi. northeast of Blackwood and between one half to one mile east of Belair Railway Station, just south of Sheoak Rd.; this habitat

differed considerably from the Blackwood locality in having a far better representation of the heath or scrub elements (smaller evergreen sclerophyll bushes) of the original Mt. Lofty Range flora.

Western Australian records given as "Drummond Cove, \pm seven mi. N of Geraldton" are based on four years of collecting (uv. lights and hunting for larvae, etc.) at Lot 68, Drummond Cove, or within a short distance south of Lot 68; this is a coastal sandhill habitat dominated by *Acacia ligulata*.

A number of other moth foodplant records are also included from tropical N. Queensland, the far southwest of Western Australia, and a few miscellaneous other Australian localities; also, a supplement giving two foodplant records from the Fiji Islands follows the family Zygaenidae.

All localities named are the exact source-localities of the specimens (either of the original females from which eggs were obtained or of the field-collected larvae), regardless of whether or not they were later transported to some other locality during the process of rearing.

Climate and Seasons: I interpret the natural seasonal cycle in coastal South Australia as "beginning" with the earliest soaking rains of autumn, which is also the cycle in coastal southern California; this is a very similar Mediterranean climatic pattern, except for the six-month-reverse in seasons and a somewhat higher (but unreliable) rainfall in the South Australian spring and summer. The coastal S. Aust. wet season is cool to cold, followed by a relatively long dry season that is warm to hot with only occasional precipitation in the form of unpredictable summer thunderstorms in some years.

In mild-temperate South Australia (Adelaide vicinity), the seasons can be interpreted roughly as follows: *late March to about early May* = autumn (warm to chilly; semi-dry grading to wet); *about mid May through August* = winter (mild to cold; mostly wet); *September to about early November* = spring (chilly to warm; wet grading to semi-dry); *about mid November to mid March* = summer (cool to hot; mostly dry).

Average annual rainfall at Blackwood, S. A., as gleaned from records kept in the local Post Office (1929-1969), was 26.75"; it had been as low as 13.71" (1967) and as high as 38.20" (1968), during this 41-year period. Snow rarely falls, but traces may be seen in the Mt. Lofty summit area once or twice in most winters. Average monthly rainfall, in inches, has been as follows (1929-1969): April = 2.44"; May = 3.43"; June = 3.41"; July = 3.63"; Aug. = 3.21"; Sept. = 2.56"; Oct. = 2.31"; Nov. = 1.62"; Dec. = 1.26"; Jan. = .89"; Feb. = 1.05"; March = .94". The seasonal breakdown of this precipitation pattern (rounded off to the nearest inch) turns out thus: autumn = 4"; winter = 13"; spring = 6"; summer = 4" (Blackwood, S. Aust.).

Temperatures: Nocturnal winter lows rarely drop below 34°F.; diurnal summer highs rarely surpass 102°F. (usually in the 70's, 80's, and low 90's) in the Blackwood district. July is usually the coldest month of the year (or June-mid August); Jan.-Feb. are usually the warmest months, and can be very hot for brief periods.

Foodplants: All foodplant names listed here have been carefully checked in the various floras available at the time I was doing this work, and difficult or variable plants were also submitted to specialists for determination (see Acknowledgments). Since residence began in W. Aust. (July 1972), most larval foodplants are now being collected, pressed, and deposited in the W. Aust. Herbarium (Perth). The family is named at least once for every foodplant genus, but to save space the author citations and families of the Blackwood or Belair plants appearing most frequently in the list are given only once, in the following section on Vegetation. The system of plant classification employed here (above the generic level) mostly follows a recent world synopsis of flowering plants by Thorne (1968); for additional details on this topic, see McFarland (1970 and 1975: 113). Only standard family name endings (-aceae) are used. An asterisk (*) preceding the name of any plant implies that the species is introduced (naturalized and growing wild) in the locality named, but was not originally native there.

The words "on" or "accepted," preceding the name of the plant, convey subtle but important differences: "on" implies that I know (from field observation) that the plant listed is a natural foodplant of the moth in the named locality, whereas "accepted" (or "acc.") implies that the larvae were reared from eggs in captivity, and that they chose the named plant from a selection of samples offered by me, but I have no positive field evidence that they are necessarily to be found on that plant under natural conditions. However, if the larvae did not thrive upon an offered plant and successfully produce normal adults, the plant has not been listed here as "acceptable." Most of these cases probably do represent the actual foodplant(s) used in the locality, unless the larvae were reared in some locality other than that where the original ♀ was collected; only a few cases of this nature are reported here.

The larvae may be presumed leaf-feeders if some other part of the foodplant is not specifically named. The distinction between young (new) leaves and mature (old or tough) leaves is often of great importance, particularly in connection with evergreen sclerophyllous plants; this has been consistently reported if such preferences could be discerned in the larval feeding habits.

Vegetation: As the majority of records in this paper are from the Blackwood-Belair district of S. Aust., a brief characterization of the flora,

as it was in that locality between 1965 and 1970, seems desirable. The native plants of the district composed a variable forest-and-scrub mixture of evergreen sclerophyll trees and shrubs (of many sizes), also including many grasses, sedges, bulbs, annual herbaceous plants, mosses, and a few ferns, etc.

Family MYRTACEAE: *Eucalyptus odorata* Behr. ex Schldl. (peppermint box or mallee box) and *E. leucoxylon* FvM. (blue or yellow gum or white ironbark) were the two dominant **trees** around Blackwood (especially the former). MIMOSACEAE: *Acacia pycnantha* Benth. (golden wattle) was abundant, growing as a large shrub or small tree under and among the eucalypts. *Casuarina stricta* Ait. (drooping sheoak, also a tree) was fairly common in some parts of the district. In the Belair National Park, S. of Sheoak Rd., *Eucalyptus fasciculosa* FvM. (pink gum) was a locally common tree, while at slightly higher elevations nearby, *E. obliqua* L'Herit. (messmate stringybark) becomes abundant and *E. viminalis* Labill. (manna gum or ribbon gum) is not uncommon. At lower elevations (mainly along watercourses) *E. camaldulensis* Dehnh. (river red gum) occurs.

The remainder of the native woody plants were mostly **shrubs** (many sizes), of which the more important species are here listed alphabetically by family. ASTERACEAE: *Olearia ramulosa* (Labill.) Benth.; CASUARINACEAE: *Casuarina muelleriana* Miq. ("oak bush"); DILLENIACEAE: *Hibbertia exutiacies* Wakefield (syn. *acicularis*), *H. sericea* (R. Br. ex DC.) Benth., and *H. stricta* (DC.) FvM; EPACRIDACEAE: *Astroloma conostephioides* (Sond.) FvM. ex Benth. and *A. humifusum* (Cav.) R. Br. (native "cranberry"); FABACEAE: *Dillwynia hispida* Lindl., *Hardenbergia violacea* (Schneev.) Stearn (native "lilac," a woody vine), and *Pultenaea largiflorens* var. *latifolia* H. B. Williamson; HALORAGACEAE: *Haloragis elata* A. Cunn. ex Fenzl and *H. heterophylla* Brongn. (not woody); LAURACEAE: *Cassytha glabella* R. Br. and *C. pubescens* R. Br. ("dodder"—both are perennial, twining parasites of various shrubs); LORANTHACEAE: *Amyema miquelii* (Lehm. ex Miq.) Tiegh. (the common pendulous mistletoe, parasitic only on *Eucalyptus* spp. here); MIMOSACEAE: *Acacia armata* R. Br. ex Ait. (Kangaroo thorn; common locally, but almost nothing seems to eat it) and *A. myrtifolia* (Sm.) Willd. (common understory shrub at slightly higher elevations nearby); MYRTACEAE (shrubs only): *Calytrix tetragona* Labill. and *Leptospermum myrsinoides* Schldl. (a slender, erect shrubby "tea tree"); PITTOSPORACEAE: *Bursaria spinosa* Cav.; POLYPODIACEAE: ¹*Pteridium esculentum* (Forst. f.) Nakai (brack-

¹ In Family DENNSTAEDTIACEAE according to Lamp & Collet (1976).

en)—not woody, but an important perennial where locally common; PROTEACEAE: *Banksia marginata* Cav. ("honeysuckle"), *Grevillea lavandulacea* Schldl., *Hakea rostrata* FvM. ex Meisn. (needle bush), and *Isopogon ceratophyllus* R. Br.; SANTALACEAE: *Exocarpos cupressiformis* (Labill.) (native "cherry"; a large, shrubby root parasite); SAPINDACEAE: *Dodonaea viscosa* Jacq.; XANTHORRHOEACEAE: *Xanthorrhoea semiplana* FvM. (Blackboy, grass tree, or yacca; locally common in the NW corner of Belair National Park).

Of the above-listed native plants, undoubtedly by far the most important foodplant genus in the Blackwood-Belair locality (throughout the year) is *Eucalyptus*, for maximum species of moth larvae feeding upon it; both new and old leaves are important. A close second in importance (at Blackwood) would be *Acacia pycnantha* (from June–Oct.), but none of the other local acacias. Following these would be a relatively small number of the other plants, the more important foodplants among them being *Casuarina* (both listed species), *Hibbertia* (only the last two species listed), *Pultenaea largiflorens* var. *latifolia*, *Cassytha pubescens*, *Amyema*, *Leptospermum myrsinoides*, *Hakea rostrata*, and *Exocarpos*. Of these, one of the most important (from July–Oct.) is *Pultenaea largiflorens*, in the Blackwood area; the other plants just named occur primarily in the NW corner of Belair National Park, or only in very small and scattered remnant patches closer to Blackwood.

At higher elevations in Belair National Park and elsewhere in the Mt. Lofty Range, grow numerous other native plants (both woody and herbaceous), but they are not listed here because these localities are fairly distant from the area in which most of my collecting was concentrated. Some of the moths rated as only "B-" or "C" or "D" in abundance at Blackwood may well be far more common at higher elevations, or in localities further to the south, where more of the original flora still grows relatively undisturbed and in more extensive tracts.

Unfortunately, many introduced woody plants (several of them highly successful and aggressive) are naturalized and extremely abundant in the Blackwood-Belair district. Notable among these are the following, of which the first-named is perhaps the worst: Boneseed, *Chrysanthemoides monilifera* (L.) T. Norl. (Asteraceae); Canary Is. broom, *Genista* (*Cytisus*) *maderensis* (Webb & Berth.) Lowe (Fabaceae); furze, *Ulex europaeus* L. (Fabaceae); *Crataegus* sp., *Rosa* sp., and a blackberry, *Rubus* sp. (all Rosaceae); *Olea europea* L. (olive). *Chrysanthemoides monilifera* is steadily advancing into the undisturbed patches of smaller native plants and is smothering out all smaller species (and even including many well-established larger shrubs) as it advances. Unless the "experts" responsible for the fate of the one excellent small remnant

patch of native heath plants still growing a short distance south of Adelaide (centering about $\frac{3}{4}$ mi E of Belair Railway Station) suddenly develop foresight, and become motivated to take the physical action (*i.e.*, *work!*) necessary to eradicate the *C. monilifera* menace from that area (without harming the native plants), little will remain there worthy of preservation in another decade. *C. monilifera* is, incidentally, one of the *easiest* sizeable shrubs to pull up by hand that I have ever encountered. I pulled up hundreds in this locality (1966-69).

Of the naturalized weedy herbaceous plants, *Arctotheca calendula* (L.) Levyns (capeweed or cape dandelion) (Asteraceae) from S. Africa, and *Echium lycopsis* L. (known as "Salvation Jane" in S. Aust. and "Paterson's Curse" in W. Aust.) (Boraginaceae), are among the most abundant and conspicuous species growing in disturbed open places throughout the district. Other conspicuous weeds here are several S. African Liliaceae (bulbs), *Oxalis pes-caprae* L. (Soursob), *Plantago lanceolata* L., *Polygonum ?aviculare* L. (wireweed), and various introduced grasses.

Acknowledgments and Determinations: All names used in the list that follows were based on the associated adult moths (those bearing code-numbers on blue labels). Many of these moths have been matched with the type specimens. Sources of determinations used here (both entomological and botanical) are abbreviated as follows: BH = B. Hyland and A. Irvine of the Forestry Regional Research Station, Atherton, Queensland (N. Qld. plants); IC = I. F. B. Common of the Australian National Insect Collection, C.S.I.R.O., Canberra, A.C.T., helped with the majority of moths in this study (all families); MK = the late Mrs. M. Kenny of the South Australian Museum, Adelaide (S. Aust. plants); NM = the author (some specimens so designated were also submitted to specialists for verification); SF = D. S. Fletcher, and his assistant, Mrs. K. Smiles, of the Entomology Department, British Museum (Natural History), London (primarily geometrids and some miscellaneous moths); Fletcher also reviewed the manuscript in 1973 and offered helpful suggestions. WAH = various taxonomists of the Western Australian Herbarium, Jarrah Rd., South Perth (since 1968), and P. G. Wilson in particular (W. Aust. plants).

I am deeply indebted to D. S. Fletcher and I. F. B. Common for their frequent and generous assistance, since 1965, with numerous difficult moth determinations, sometimes involving the preparation of genitalic slides and thus the expenditure of much time on my behalf; without their help, publication of these records would have been very difficult. In the case of my own determinations (NM), they were obtained primarily from studying material in the extensive South Australian Museum moth

collection (Adelaide) while I was on the staff there, supplemented by careful examinations of other major collections in Melbourne, Sydney, Canberra, Brisbane, and London (BMNH only). My interpretation of moth families (and superfamilies) follows Common (1970: 782-83). Plant determinations (other than above-credited) were obtained primarily by careful keying in the floras available for the various regions at the time of this study (see References). Mr. T. R. Newbery (TN), of Murray Bridge, S. Aust., kindly provided a number of his foodplant records, which are included in the list; his companionship in the field, upon numerous occasions, will always be remembered with pleasure. Similar pleasant memories are also associated with past field trips in the company of Mr. K. J. Sandery (St. Agnes, S. Aust.), and the late Mr. and Mrs. J. O. Wilson of Glenelg (see McFarland, 1974). The Sandery and Wilson moth collections, while not large, contained many specimens of interest. The Wilson Collection has gone to the A.N.I.C. I would also like to thank my former landlady, Mrs. L. Henley, for her unfailing tolerance of my strange nocturnal pursuits in her back garden during my nearly 6 years of residence at 2 Gulfview Rd.; my wife, Dienie, for assisting at home and afield in various aspects of this work, for cheerfully sharing her home with hundreds of lepidopterous larvae during the first years of her marriage, and for expertly typing this manuscript. Appreciation must also be registered for her patience in coping with a grossly overloaded refrigerator, which was periodically choked with plastic bags containing larval foodplants!

Abbreviations & Symbols: acc. = accepted; det. = determined by; fl., fls. = flower(s); fr., frs. = fruit(s); "H." (before a date) implies the date of adult emergence from a pupa in captivity; lf. = leaf; lvs. = leaves; nr. = near; "orig. ♀" = the original female from which eggs were obtained in confinement; \pm means more-or-less, about, or approximately; an asterisk (*) before the name of a plant (or moth) indicates that the species is introduced or not originally native to the locality named. For convenience and quick reference, all moths are arranged *alphabetically* from the family down. Australian states are abbreviated as follows in the list: QLD. = Queensland; N.S.W. = New South Wales; N. TERR. = Northern Territory; S. AUST. = South Australia; TAS. = Tasmania; VIC. = Victoria; W. AUST. = Western Australia.

Terminology for Adult Resting Positions: The following terms are used for the three major categories of resting positions commonly seen in adult Macrolepidoptera: (1) *tectiform* = the forewings held more-or-less roof-like over the abdomen, upper surfaces exposed, with the hindwings more or less completely hidden beneath (seen in many noctuids and arctiids, etc.); (2) *planniform* = all wings more or less flatly ap-

pressed to the substrate, commonly with some degree of hindwing exposure (seen in numerous geometrids); (3) *veliform* = the typical butterfly position of "total rest," with all wings held erect over the dorsum, the upper surfaces tightly closed together, sail-like. The veliform position is also seen in a few geometrids such as the Australian oenochromine, *Hypographa aristarcha*, and the North American genera *Fernaldella* and *Stamnodes*, etc. *Xanthorrhoe* and *Hydriomena* spp. also sometimes exhibit this position *temporarily* (when just landed), but usually revert to planniform later (when at "total rest"). Aside from a few geometrids, I know of no other Australian moths that use the veliform position.

The first term is well-known, but I have never seen the other two used before, so am proposing them here. There are numerous subtle variations on these three major themes, which can usually be adequately described and compared simply by indicating the degree of exposure of the hindwing; this can be expressed as a percentage. Any rolling or folding of wings or margins should also be noted, as well as any tendency to clasp a branch or twig with the forewings (for anchorage). Examples of the latter are often encountered in windy climates. Among others, Australian ennomine geometrids of the genera *Capusa*, *Lophothalaina*, and *Stathmorrhopa* have this clasping habit well developed. When at rest, *Capusa* spp. also partially fold the forewings fan-like, in a most peculiar and distinctive fashion, which causes them to appear much narrower distally than they actually are when the wings are spread.

THE LIST

NOTE: All plants **not** showing family names or author citations in the list below are discussed under **Vegetation** (pp. 9-11), where this information is given once in full for each of these common South Australian species.

AGARISTIDAE

• *Agarista agricola* (Don.) (det. MM)—As.12. N.QLD., nr. Ravenshoe, at Millstream Falls (J. Wrigley, collector): Larvae (May-June 1972) conspicuous on a vine, *Cissus* sp. (probably *C. opaca* FvM.); captive larvae accepted (as a substitute) another vine, *Cayratia ?clematidea* (F. Muell.) Dom.—both VITACEAE (dets. BH). Adults diurnal. See Common (1966b: 71-color; 1970: 863) for illus. of adult. (Preserved = 5, 9; photos = 5.)

• *Apina callisto* Walk. (det. NM)—As.8. S.AUST., Adelaide, suburb of Walkerville, just NW of Kingston Tce. at Francis St., in the city parklands (NM, collector): Larvae (late July-early Sept.) extremely abundant only within the limits of a small and restricted "colony," in a large grassy-weedy field (paddock), feeding primarily on the S. African annual weed, Cape dandelion, **Arctotheca calendula*; a few larvae seen feeding on two other low-growing weeds, **Malva* sp.—MALVACEAE, and **Rumex* sp.—POLYGONACEAE; one larva seen feeding on a *grass—POACEAE (dets. NM). Larvae are diurnal feeders and need sun to elicit vigorous feeding.

Adults (B+) fly mid April–mid May (univoltine) and are strictly diurnal; flight mostly confined to very restricted areas of the general habitat. See Common (1966b: 121) for photos of larva and adult; McFarland (1970: 350 & 1972b: 227) for egg photos. (Preserved = 1–6, 8dd, 9; photos = 1, 2, 6.)

• *Comocrus behri* (Angas) (det. NM)—As.5 & 5A. (1) S.AUST., Blackwood-Belair district (NM): Larvae (Jan.–April) conspicuous (but widely-scattered) on the pendulous mistletoe, *Amyema miquelii* (det. NM), which is parasitic on many gum trees, *Eucalyptus* spp. Adults (B) fly late Nov.–March (peak Jan.); diurnal only. (2) S.AUST., \pm 30 mi. S of Whyalla, at Murninnie Beach (B. Flounders, collector): Larvae (April 1969) common on *Amyema melaleucæ* (Lehm. ex Miq.) Tiegh., which was parasitizing *Melaleuca lanceolata* Otto—MYRTACEAE (dets. MK). For a discussion of diurnal hilltopping behavior in W. Australian adults of this sp., see McFarland (1976). See Common (1966b: 121) or Tillyard (1926: Pl. 36) for adult photos. (Preserved = 1, 5, 6, 9; photos = 5, 6.)

Cremnophora angasi Walk.—see Noctuidae.

• *Hecatesia exultans* Walk. (det. IC)—As.11A. W.AUST., 22–24 mi. ESE of Hyden, at roadside (D. & NM): Larvae (late Oct.) conspicuous, sunning and feeding on the young (red) growing tendrils of devil's twine or Australian "dodder," *Cassytha* sp., which was commonly parasitizing a shrubby *Casuarina* sp., as well as other plants in the area (dets. NM). Adults fly in spring and summer; peak of δ activity probably crepuscular; peak of ϕ activity probably evening and/or nocturnal. Sexual dimorphism is apparent. (Preserved = 1, 5, 6, 8d, 9.)

• *Hecatesia thyridion* Feisthamel (det. SF)—As.9 & 9A. (1) S.AUST., Mt. Lofty Range, Upper Sturt, nr. Ironbank Rd. (NM, TN, & P. Taverna): Larvae (Feb.–April) at rest and feeding (diurnally) on young tendrils of *Cassytha pubescens* and *C. glabella* (dets. MK), parasitic twiners on many shrubs in this locality. Adults (B, very local) fly Jan.–March; peak of δ activity probably crepuscular, after hot days; peak of ϕ activity probably nocturnal (occasional individuals of both sexes come to uv. light). There may also be a spring emergence (Oct.–Nov. \pm). Sexual dimorphism is apparent. See Common (1966b: 123) for δ adult photo; Common (1970: Pl. 8, color) for δ adult of *H. fenestrata* Bdv. (Preserved = 1, 2, 5, 6, 8d; photos = 2, 5, 5c, 6.) (2) W.AUST., 13 mi. E of Tambellup, at roadside (NM & N. B. Tindale): One larva (21 Nov. 68) on young growth of *Cassytha* sp., which was parasitizing *Melaleuca uncinata* R. Br. ex Ait.—Myrtaceae (det. NM). (Preserved = 5, 9.)

• *Periscepta polysticta* (Butl.) (det. IC)—As.7. S.AUST., S coast of Kangaroo Island, 2½ mi. S of Mt. Taylor (\pm 10 mi. W of Vivonne Bay), on land of G. D. Seton (NM): Larvae (Dec.–Jan.) locally common on the dwarf shrub, *Hibbertia fasciculata* R. Br. ex DC. (det. MK). Adults (B) fly Oct.–Nov., diurnal only. See Common (1966b: 123) for adult photo. (Preserved = 1, 5, 6, 9; photos = 1.)

• *Phalaenoides glycine* Lew. (det. NM)—As.6. (1) S.AUST., Blackwood (NM): Larvae (Oct.–April) common on cultivated grape vines, **Vitis* spp.—VITACEAE; also several in garden (Nov. 69) feeding avidly on lvs. of an introduced Californian evening primrose, **Oenothera hookeri* T. & G.—ONAGRACEAE (dets. NM). (2) S.AUST., N of Penola (NM & D. Lee): Larvae (Dec. 64) on a small annual *Epilobium* sp.—ONAGRACEAE (det. NM), at the edge of a road. (Interestingly, this same contrasting combination of foodplant families, although involving various plant genera and species, is also known for some of the North American agaristids and sphingids.) Adults (B) fly mid Sept.–Mar. (peak Nov.–Jan.), diurnal only. See Common (1966b: 121) for adult photo; Common (1970: 858) for line drawings of larva and pupa. (Preserved = 1, 5, 6, 9; photos = 5, 6.)

• *Sarbanissa* (*Seudyra*) *hostrychonota* Tams—see Supplement on Fiji (following Zygaenidae).

ANTHELIDAE

• *Anthela denticulata* Newman (det. NM)—An.1. S.AUST., Adelaide and Blackwood districts (NM): Larvae (July–Sept.) locally common on various naturalized

and native grasses (esp. "soft" annual spp.)—POACEAE, in weedy pastures, vacant lots, along roadsides, or in comparable situations. The larvae are diurnal feeders and seek the sun. Adults (B) fly mid March–April, especially after 2300 hrs; univoltine. (Preserved = 1–7, 9; photos = 2.)

• *Anthela glauerti* Turner (det. IC)—An.19. W.AUST., \pm 125 mi. S of Carnarvon, at the "Overlander Roadhouse" (D. & NM): Orig. ♀ (13 July 77) had come to lights the night before. Readily oviposited in a jar (on a muslin strip). Captive larvae (reared at Drummond Cove, W.Aust.) readily accepted *Acacia ligulata* (det. NM); new lvs. preferred. A second generation mating of this very small anthelid was obtained in captivity (Sept. 78), and some of these eggs were frozen for perfect specimens before hatching; 1977 eggs were preserved as empty (hatched) shells. (Preserved = ♂ ♀ 1, 2, 3–5♀, 6, 7♀.)

• *Anthela ocellata* (Walk.) (det. NM)—An.4. S.AUST., Adelaide city suburbs, in gardens and vacant lots, etc.: Larvae (Nov.–June) seen feeding on various naturalized annual grasses, and on mixed lawn grasses—POACEAE. Adults (B) fly spring–autumn. This sp. appears to be far more abundant in city gardens, parks, and other cultivated areas than it is in areas where the native flora predominates. See Common (1966b: 93) for ♂ adult photo. (Preserved = 1–7, 9; photos = 2.)

• *Anthela* sp. nov. (det. IC); close to *repleta* Warren (det. SF)—An.7 & 7A. (1) S.AUST., 5 mi. E of Two Wells, at roadside (NM & TN): Larvae (Aug.–Sept.) on *Cassia nemophila* Cunn. ex Vogel—CAESALPINIACEAE (det. MK). (Preserved = 1, 4–6.) (2) S.AUST., Blackwood-Belair district (NM): Larvae (Sept.–Oct.) rest in full view on young lvs. of golden wattle, *Acacia pycnantha* (det. NM). Adults (B) fly late April–July (peak June), often on very cold winter nights when little else is on the wing. ♂ & ♀ quite diff. in color (♀ usually much paler); univoltine. (Preserved = 1–7, 9; photos = 1, 2.)

• *Anthela* sp.; close to (but not) *guenei* Newman (det. IC)—An.11. S.AUST., at Kingoonya, approx. 400 mi. NW of Adelaide (M. McFarland, NM, & V. Lill): Larvae (late March) common on *Cassia nemophila* vars. and one other *Cassia* sp.—CAESALPINIACEAE (dets. NM); these plants were full of luxuriant new growth, in response to heavy rains several weeks earlier. Adults probably fly between Sept. and March, whenever rains break the pupal diapause during warm or hot weather (a desert locality, with variable and unpredictable rainfall). Reared specimens from this series are also in the K. D. Fairey & V. J. Robinson collections. (Preserved = 1, 5–7, 9.)

• *Anthela* sp., probably *xantharcha* Meyr. (det. NM)—An.12 & An.18. S.AUST., inland desert, 4½ mi. NNW of Coober Pedy, in a small, rocky, dry creek bed (M. McFarland, NM, & V. Lill): Several conspicuous masses of large opaque, pure white eggs (23 March 69) were found attached to lvs. in the tops of *Eremophila freelingii* FvM.—Myoporaceae (large bushes), almost certainly not one of its foodplants; a *Cassia* sp. (the probable foodplant) was growing nearby. Captive larvae (reared at Blackwood, S.Aust.) readily accepted young lvs. of *Acacia pycnantha* (dets. NM) and grew well. They entirely refused lvs. of a few *Myoporum* and *Eremophila* spp. offered to them, but *E. freelingii* was not among the samples. For notes on the early stages of a W. Australian *xantharcha* population, see Mills (1954). (Preserved = 1–7, 8h ex egg; photos = 2.)

• *Anthela* sp. (det. IC)—An.14. (1) N.QLD., \pm 9 mi. W of Mareeba (J. Wrigley): Larva (3 June 72) on mature lvs. of a poisonous tree, Cooktown ironwood, *Erythrophleum chlorostachys* (F. Muell.)—FABACEAE (det. BH). The resulting ♂ adult (H. 23 Sept. 72) and its cocoon and pupal shell are in the A.N.I.C. (Canberra). (Preserved = 1, 4, 6, 7, 9.) (2) N.QLD., 16 mi. SW of Conjuboy Homestead (\pm 2400' el.), N of Hughenden (D. & NM): Nearly fullgrown larva (21 June 72), identical to the above, at rest among mature lvs. of *E. chlorostachys*, \pm 12 feet up in the tree. (Preserved = 5.)

• *Munychryia periclyta* Common & McFarland (1970) and *M. senicula* Walk. (det. IC)—"N."109. Larvae of both are feeders upon the foliage of various *Casuarina*

spp. and are described in detail (including life history photos of all stages of *M. senicula*) by Common & McFarland (1970). "N."109 refers only to *senicula* (in S. A. Museum). Adults of *senicula* (Belair district, S.AUST.) fly in spring-summer. See also Common (1970: 850) for ♂ adult photo. (*M. senicula* only: Preserved = 1-7, 9; photos = 1, 2, 4-7.)

• *Pterolocera* sp., close to *amplicornis* Walk. (det. NM)—An.6 & 6A. (1) S.AUST., Hallett Cove, coastal bluffs ± 10 mi. S of Adelaide (D. & NM & K. D. Fairey): Larvae (June-Aug.) extremely common locally, most often on (or very near) the ground, concentrated in suitable habitats, sunning and feeding (diurnal only) on low-growing plants, primarily on tender naturalized (annual) and tough wiry (perennial) native grasses—POACEAE; also seen feeding (occasionally) on the very tough-wiry lvs. of *Gahnia lanigera* (R. Br.) Benth.—CYPERACEAE (dets. NM). These larvae drink (dew or rain) copiously at times, and they also require plenty of fresh air, as well as sun (periodically); if any of these needs are totally ignored they will not thrive in captivity. Adults (♂♂ only) have a brief but concentrated flight in autumn (\pm April), when they search for the wingless ♀♀. Sexual dimorphism is spectacular. See Common (1966b: 241 or 1970: 850) for ♂ adult photo of *amplicornis*; McFarland (1970: 349 & 1972b: 223) for egg photos. (Preserved = 1, 2, 4-7, 8ddd, 9; photos = ♂ 1, 2, 5, ♂♀ 6, 7.) (2) S.AUST., S. coast of Kangaroo Is., at Seal Bay (NM, M. Pate, & G. D. Seton): Larvae (16 Oct. 66) abundant, wandering over the sand in association with larvae of my Ar.34A (Arctiidae), and the even more abundant Lp.12 (Lymantriidae); seen feeding (diurnal) on various small herbaceous spring ephemerals, as follows: *Crassula* sp.—CRASSULACEAE; *Daucus glochidiatus* (Labill.) Fisch., Mey., & Avé-Lall., and *Hydrocotyle* sp.—both APIACEAE; also one eating (perennial) **Poa bulbosa* L.—POACEAE (dets. MK). (Preserved = 1, 5, 6, 8d, 9.)

• *Pterolocera* sp. (det. IC)—An.2 & 2A. (1) S.AUST., Mt. Lofty Range, in Belair Nat. Park, just S of Sheoak Rd. (NM): Larvae (July-Oct.) feeding both at night and diurnally, on many unrelated plants, both woody shrubs and tough, wiry perennial bunch-grasses. Specific records: Older larvae (in this locality) seem to show a preference for nocturnal feeding on the tough, needle-like, sclerophyll old lvs. of *Hakea rostrata*; one seen feeding (mid Aug.; day) on *Casuarina striata* Macklin. (dets. MK). Adults (♂♂ only) have a brief but concentrated flight in autumn (mid March–April or May), when they search for the wingless ♀♀. Sexual dimorphism is spectacular. (Preserved = 4, 5, 9.) (2) S.AUST., Kangaroo Is., 2½ mi. S of Mt. Taylor (± 10 mi. W of Vivonne Bay), on land of G. D. Seton (NM): Larvae (mid Oct.) abundant, but widely-scattered throughout the native (sclerophyll) scrub of this locality; in daytime usually up in various bushes, not on the ground (unlike An.6 & An.6A); feeding both day and night on the tough, mature lvs. of their foodplants. Specific feeding records (based on field observations): *Casuarina striata* Macklin.; *Hakea ?muelleriana* Black; *Daviesia brevifolia* Lindl. and *Platylobium obtusangulum* Hook.—both FABACEAE; *Choretrum spicatum* FvM.—SANTALACEAE (dets. MK). Larvae brought back to Blackwood readily switched over to *Acacia pycnantha* as a substitute foodplant. (Sun not imperative for this species in captivity, but ample ventilation is desirable—also an occasional sprinkling.) See McFarland (1970: 349 & 1972b: 223) for egg photos. (Preserved = 1-7, 8h, 9; photos = ♀ 1, 2, ♂♀ 6.)

• *Pterolocera* sp. (det. IC)—An.10. W.AUST., Stirling Range, along roadside nr. Toolbrunup Peak, ± 200 mi. SE of Perth (NM & N. B. Tindale): Small larvae (19 Nov. 68) fairly common on young lvs. of (only) the low shrub, *Banksia sphaerocarpa* R. Br. (det. RR). Readily accepted young lvs. of *B. marginata* as a substitute foodplant, when taken 1200 mi. E to Blackwood; grew to full size, in excellent condition, on the latter. (No apparent urgent need for sun in captivity, but ample ventilation and a light sprinkling every day or two are desirable.) The adult ♀ is wingless; sexual dimorphism is spectacular. This sp. shows a kinship with my An.2, in the

general appearance of adults, the egg shape (profile), and the larval behavior, but it is easily separated and is probably a distinct species.

Mites: I have never seen any lepidopterous larvae more heavily mite-infested than were some of the younger individuals of this sp. when first collected! (See also remarks under Carthaeidae.) These vivid red mites were later det. by Dr. R. V. Southcott (Adelaide) as *Charletonia feideri* Southcott, 1966 (ref. *Aust. J. Zool.* 14: 752) of the Erythraeidae, Sbf. Callidosomatinae, Tribe Charletoniini. (Preserved = 1-7, 8m, 9; photos = 2, 5.)

• *Pterolocera* sp. (det. NM)—An.20. W.AUST., Moresby Range, \pm 19 mi. NNE of Geraldton, at Howatharra Hill Reserve, especially in Zones 5 and 10 (D. & NM): Larvae (Aug.–Oct.) abundant most years, usually seen feeding, sunning or at rest on grasses or sedges, esp. *Lepidosperma*. The short middorsal setae form a conspicuous pinkish-white line in this population; I have not as yet reared or collected any adults. These larvae are clearly distinct from An.10, but might prove to be a sp. of An.6 or An.2. (None preserved at time of writing.)

General remarks on the foregoing Pterolocera spp.: These 4 incomplete determinations were included in the list because of the good differences in larval appearance, morphology, coloration, behavior, and foodplant preferences; also, the eggs are easily separated by differences in the coloration, maculation, and measurements (proportions). The ♂ adult moths, however, are of rather similar appearance, somewhat variable in coloration, and sometimes inclined to overlap in this variability; the species are very often mixed up in collection series. All four are univoltine.

ARCTIIDAE

(A) SUBFAMILY ARCTIINAE

• *Amsacta marginata* (Don.) (det. IC)—Ar.46. W.AUST., Northampton (NM): Larvae (July–Sept.) wandering rapidly over ground in open, grassy-weedy areas; on numerous low-growing, herbaceous plants, including **Arctotheca calendula* and **Echium lycopsis*, etc. (dets. NM). These larvae are fairly common here, but far less abundant than those of *S. glatignyi*, which occur in exactly the same places at the same season. The *Amsacta* larvae are quickly identified by their more rapid locomotion and less-dense setae; univoltine here, with adults emerging in autumn (\pm). See Common (1966b: 72, 111) for color illus. and photo (B. & W.) of adult. (Preserved = 1, 5, 6.)

Ardices—see *Spilosoma*.

• *Spilosoma canescens* Butl. (det. NM)—Ar.41. S.AUST., higher parts of the Mt. Lofty Range, Aldgate district (NM): Captive larvae (Jan.) readily accepted numerous offered plants (both herbaceous and woody). Three woody plants for which they showed a great liking were lvs. of ash, **Fraxinus* sp.—OLEACEAE; apple, **Malus* sp.—ROSACEAE; pine, **Pinus* sp.—PINACEAE (dets. NM). *Pinus*, in particular, was eaten avidly! Adults (local; B-) fly Nov.–Jan.; in 5 yrs. never recorded at Blackwood or other lower elevations near Adelaide. Probably univoltine. See Common (1970: 857) for adult photo. (Preserved = 1-4, 9.)

• *Spilosoma glatignyi* (LeGuill.) (det. IC)—Ar.34 & 34A. (1) S.AUST., Blackwood-Belair-Eden Hills (NM): Larvae (June–mid Oct.) exceedingly common most years, primarily on various low-growing herbaceous plants or shrubs, often becoming pests in gardens. Some of the “primary” foodplants: **Echium lycopsis*, **Genista maderensis*, *Pultenaea largiflorens* var. *latifolia*, **Arctotheca calendula*, **Chrysanthemoides monilifera*, *Olearia ramulosa*, and **Plantago lanceolata* (dets. MK). Of the above, the first two listed are perhaps the most important foodplants of this moth around Blackwood. In addition to the above-listed, I have seen them feeding on numerous other plants, both native and naturalized; univoltine. Adults (A+) fly mid Jan.–mid May (peak April); the majority come to uv. light mostly after 2300 hrs. See Common (1966b: 111) or Tillyard (1926: Pl. 33) for adult photo. (Pre-

served = 1, 4-6, 8dd, 9; photos = 1c, 6.) (2) S.AUST., S coast of Kangaroo Is., at Seal Bay (NM, M. Pate, & G. D. Seton): Fullgrown larvae (16 Oct. 66) crawling over the sand, in association with larvae of my An.6A (Anthelidae) and Lp.12 (Lymantriidae); seen eating the same herbaceous plants as listed for the latter.

• *Utetheisa lotrix* (Cram.) (det. NM)—Ar.36. N.TERR., 15 mi. S of Mataranka, at Warlock Ponds (NM): Larvae (9 April 66) on lvs. and floral parts of *Crotalaria trifoliastrium* Willd.—FABACEAE (det. NM). See Common (1966b: 111) for adult photo. (Preserved = 4-6, 9.)

• *Utetheisa pulchelloides* Hamps. (det. SF)—Ar.35, 35A, & 35B. (1) S.AUST., Blackwood and Eden Hills, on open & dry-grassy slopes (NM & J. Herridge): Larvae (9 Jan. 66) commonly feeding on floral parts of **Echium lycopsis* (det. NM). Adults (A+) fly Sept.-mid May (peaks Dec.-Feb. & April). (Preserved = 1, 4-6, 8d, 9.) (2) S.AUST., 4 mi. E of Two Wells, in dry, weedy-grassy paddocks and at roadsides (NM, TN, & G. Furness): Larvae (19 March 67) exceedingly common on potato weed, **Heliotropium europaeum* L.—BORAGINACEAE (det. MK). (3) S. AUST., Adelaide suburb of Heathpool (R. Edwards): Larvae (30 April 67) in a garden, defoliating the ornamental forget-me-not, **Myosotis* sp.—BORAGINACEAE (det. NM).

(B) SUBFAMILY LITHOSIINAE

• *Palaeosia bicosta* (Walk.) (det. SF)—Ar.43. S.AUST., Mt. Lofty Range, Belair Nat. Park, nr. Waverley Lodge (NM & D. Bakker): Larvae (13 Sept. 69) on stems or branches of various woody native shrubs, especially *Acacia pycnantha*, feeding on LICHENS (and other minute plant growths, probably algae) that grow on the often rain-wet stem surfaces in winter and early spring. See Common (1966b: 111) for adult photo. (Preserved = 1, 4-7.)

• *Scoliacma bicolora* (Bdv.) (det. NM)—Ar.37. S.AUST., Blackwood, Hannaford Rd. (NM): Larvae (July-early Oct.) on the open or bare ground of trails through thickets of *Acacia pycnantha* and *Eucalyptus odorata*, or on \pm bare patches of firm ground, where they wander slowly over the winter-damp surface "grazing" on an abundant MOSS(!), *Pottia* sp.—POTTIACEAE (det. A. Mitchell). They are diurnal and especially crepuscular feeders, active on mild or warm days, either cloudy or sunny (if the sun is not intense or constant). Occasional individuals have also been seen eating one of the lichens, especially where these are growing on large rocks, in open but densely grass-covered paddocks (Belair district). But this common moss appears to be by far the primary foodplant around Blackwood. One larva (in captivity) was also seen eating an unidentified liverwort. Adults (B+) fly Oct.-Nov. (peak); again (B-) from Jan.-mid April. Individuals of the summer-autumn brood are generally of smaller size and less intense coloration. See Common (1966b: 72) or Tillyard (1926: Pl. 27) for adult in color; McFarland (1970: 350 & 1972b: 229) for egg photos. (Preserved = 1-7, 8dd, 9; photos = 1, 2, 5-7.)

Thallarcha—see *Xanthodule*.

• *Xanthodule ombrophanes* (Meyr.) (det. IC)—Ar.38. S.AUST., Blackwood-Belair districts (NM): Larvae (Sept.-March) on stems or branches of numerous woody plants, where they feed along the stem surfaces, probably on lichens and/or algae (exact food sources not positively identified). They are most often collected by searching over the branches of *Bursaria spinosa* and *Casuarina stricta*, or by beating *C. muelleriana* and *Exocarpos cupressiformis*; also generally encountered when beating most of the other medium-sized or larger native shrubs of this habitat. In no instance has a captive larva of this moth ever been observed feeding upon the leaves (or floral parts) of any of the numerous plants upon which they have been collected. The newly-hatched larvae have first instar dispersal behavior (see McFarland, 1973: 205-207). Adults (δ δ only; B+) fly Oct.-June (peaks Oct.-Nov.; late Jan.-early Feb.; April-May), coming to uv. light esp. after 2300 hrs. Sexual dimorphism is stupendous! The flightless (brachypterous) ♀ waits on its cocoon

for arrival of the ♂ (as in N. American lymantriids: *Hemerocampa*); after mating, all its eggs are deposited, *without* any type of covering, on the cocoon surface. For adult ♀, cocoon, and egg photos of this sp., see McFarland (1970: 350 & 1972b: 229); also Common (1966b: 109) for larval photo of a related sp. (Preserved = ♂ ♀ 1, 2-7, 9; photos = ♂ ♀ 1, ♀ 1c, 2, 2c, ♀ 6c, 7, 7c.)

(C) SUBFAMILY NYCTEMERINAE

- *Nyctemera amica* (White) (det. IC)—Ar.39 & 39A. (1) S.AUST., Blackwood (NM): Larvae (especially summer) on the S. African herbaceous, perennial vine, Cape "ivy," *Senecio mikanioides* Otto ex Walp.—ASTERACEAE (det. NM). Adults (B) recorded for all months, with peaks in Jan.-March & May-June; both diurnal and nocturnal activity, coming to uv. light esp. after 2300 hrs. See Common (1966b: 113 or 1970: 857) for ♂ adult photo; McFarland (1970: 350 & 1972b: 229) for egg photos. (Preserved = 1-6, 8dh, 9; photos = 1 pair in cop., 2, 4-6.) (2) S. AUST., nr. tip of Yorke Peninsula, ± 2 mi. NW of Jim Brown's Well (NM, N. B. Tindale, & P. Aitken): Larvae (3 Nov. 65) on the native *Senecio* aff. *lautus* Forst. f. ex Willd. (det. MK). (Preserved = 5.)
- *Nyctemera baulus* (Bdv.)—see Supplement on Fiji (following Zygaenidae).
- *Nyctemera secundiana* Lucas (det. IC)—Ar.40A. N.QLD., Atherton Tableland, 12 mi. NE of Atherton, at Tinaroo Pines Caravan Park (± 2500') (D. & NM): Larvae (April-May 72) on the soft, rank-growing Asian weed, known as thick-head, **Crassocephalum crepidioides* (Benth.) J. Moore—ASTERACEAE (det. NM). Adults both diurnal and nocturnal. (Preserved = 1-6, 9.)

CARTHAEIDAE

- *Carthaea saturnioides* Walker (det. NM)—Ca.1, 1A, 1B, 1C, & 1D. (1) W. AUST., Stirling Range, along roadside, nr. Toolbrunup Peak, ± 200 mi. SE of Perth (NM & N. B. Tindale): Larvae abundant (19 Nov. 68), along with a few unhatched eggs, on young lvs. of the low sclerophyll shrub, *Banksia sphaerocarpa* R. Br. (det. WAH). None of the vivid red mites, found so abundantly on my An.10 (Anthelidae), were seen on these larvae, although they were often closely associated, on the same bushes, with the (less numerous) An.10 larvae. Adults in this locality probably fly from Oct.-early Dec.; one fairly worn ♂ was taken at uv. light betw. 0300-0400 hrs on 20 Nov. 68; although the light was running all night, none arrived before 0300 hrs; univoltine. Duplicate copies (8 pp.) of detailed field and larval behavioral notes on this superb moth were deposited in the Lepidoptera Section of the A.N.I.C. (1968). See Common (1966a; 1970: 850, 858) for illus. of adult, larva, & pupa; McFarland (1970: 349 & 1972b: 225) for egg photos. (Preserved = 2-4, 9; photos = 1, 1c, 2, 4, 4c, 5, 5c, 6.) (2) W.AUST., 1 mi. W of Needilup (NM & N. B. Tindale): Larvae, mostly last instar & penult. (22 Nov. 68), abundant on young lvs. of the tough-sclerophyll shrubs, *Dryandra cirsioides* Meisn. and (to a much lesser extent) *Banksia caleyi* R. Br.—both PROTEACEAE (dets. WAH); the former appears to be the primary foodplant in this locality. (Preserved = 1, 5, 6, 9; photos = 1, 1c, 5, 5c, 6.) (3) W.AUST., 10 mi. E of Jerramungup (NM & N. B. Tindale): One 1st instar larva (24 Nov. 68) found feeding on the brown-pubescent young lvs. of *Dryandra pteridifolia* R. Br. (det. WAH). (There was no *D. cirsioides* anywhere nearby.) (Preserved = 3.) (4) W.AUST., 49 mi. E of Ravensthorpe, 1 mi. W of Munglinup (NM & N. B. Tindale): Last instar larvae (24 Nov. 68) feeding on young lvs. of *D. pteridifolia* and on one other unident. low-growing *Dryandra* sp., close to (but smaller than) *pteridifolia*. (*D. cirsioides* was common here but no larvae, or their unmistakable pinkish frass, could be found on it during a 30 min search by both of us.) (5) W.AUST., 9 mi. S of Ravensthorpe, on road to Hope-toun (NM & N. B. Tindale): Two 3rd instar larvae found (25 Nov. 68), on two widely-separated individuals of the linear-leaved sclerophyll shrub, *Grevillea concinna*

R. Br. (det. WAH), eating young lvs. only. This plant was in bloom at the time (deep red fls.). *Dryandra cirsioides* was more abundant than *G. concinna* at this location, but no larvae, frass, or evidence of feeding could be located on the *D. cirsioides* bushes. (6) W.AUST., Moresby Ranges, Ooakajee-Howatharra-Nanson district, between 15–25 mi. NE of Geraldton; esp. in and nr. Howatharra Hill Reserve (McFarland, 1977: 19): Larvae fairly common some years (Sept.–mid Oct.) on tender new lvs. (only) of *Dryandra fraseri* R. Br. (det. WAH); this is a dense, low-growing, extremely sclerophyll sp. with very tough and prickly mature lvs.; it grows mostly on brown lateritic gravel. Adults probably fly from about mid Aug.–early Oct. here.

COCHYLIDAE (PHALONIIDAE)

• *Hyperxena* sp. (det. IC)—46(M). W.AUST., Moresby Range, Red Peak district, ± 13 mi. NE of Geraldton (D. & NM): Larvae (2 Aug. 73) extremely abundant on the small, pink fls. & fl. buds of the large shrub, *Scholtzia ?parviflora* F. Muell.—MYRTACEAE (det. NM). The habits and behavior of these larvae are strongly reminiscent of lycaenids, as is their general appearance at first glance. The maculation is a colorful blending of pink and white, which is superbly cryptic on the foodplant inflorescences. They usually rest tightly curled around the fls. and bud clusters, almost invisible if not moving, but are easily discovered by beating if present. Adults emerged mid June 74. (Preserved = 1, 4–7, 8h, 9.)

COSSIDAE

• *Ptilomacra senex* Walk. (det. NM)—Co.29(M). S.AUST., Mt. Lofty Range, in Belair Nat. Park nr. Sheoak Rd., 1 mi. E of Belair railway station; also around Montacute, and in other localities from NE to S of Adelaide (NM): Egg masses (mid Aug.–Nov.) often found attached to the stems of various low-growing plants or bushes, including the long lvs. of *Xanthorrhoea semiplana* FvM. (det. NM), which I strongly suspect is the Belair locality foodplant. (The larvae are presumably borers.) This highly-conspicuous egg mass could not be mistaken for any other; it is composed of large numbers of very large, grayish-black eggs, tightly glued to each other with a shiny adhesive, and usually deposited in long encircling-bands. Adult sexual dimorphism and first instar larval dispersal are notable in this species. See Common (1966b: 27) for ♂ adult photo. (Preserved = 2, 3.)

GEOMETRIDAE

Among the geometrids listed here (particularly ennomines), reference is frequently made to a “rain-hatching tendency” in the eggs of certain species, or to “first instar dispersal.” These phenomena were described and discussed at some length earlier (McFarland, 1973: 203–206), so will not be repeated here. That paper was intended to directly follow a series of egg photographs published earlier (1972b), to which it frequently refers, but publication was unexpectedly delayed and several items were accidentally omitted after correction of the proofs; these are included as annotations in the list that follows.

(A) SUBFAMILY ENNOMINAE (SYNONYM = BOARMIINAE)

Amelora—see also *Diastictis* and *Loweria*.

• *Amelora crypsigramma* Lower (det. IC, NM). W.VIC., 5 mi. S of Kiata, Lowan Reserve (NM, collector): Larva (28 Sept. 67) on the woody shrub, *Baeckea behrii* (Schldl.) FvM.—MYRTACEAE (det. MK). Adult ♀ emerged 3 April 68. (Preserved = 1, 6.)

- *Amelora fucosa* Turner (det. IC)—G.183 & 183A. (1) S.AUST., nr. Port Wakefield, on top of Hummock Mt. in dense scrub (H. M. Cooper): Larvae (31 Aug. 67) on *Beyeria* sp.—EUPHORBIACEAE (det. NM). (Preserved = 5, 9; photos = 5.) (2) S.AUST., just W of Alawoona, at roadside (D. & NM): Larvae (late July 71) on the low, woody shrub, *Beyeria opaca* FvM.—(det. NM). 4 adults (all ♂♂) emerged late March—mid April 72; probably univoltine. Considerable variation is shown in forewing groundcolor, but not in maculation. (Preserved = 1, 4, 5, 6, 9; photos = 5.)
- *Amelora leucaniata* Gn. (det. SF)—G.171. S.AUST., Mt. Lofty Range, Blackwood (NM): Captive larvae (June–Aug.) readily accepted lush young lvs., buds, & fls. of the annual weed, **Polygonum aviculare* L.—POLYGONACEAE (det. NM); a preference was shown for the large-leaved, luxuriant young seedlings of this plant, which are well started (2" high \pm) by early July. Adults (C) fly March–April; those reared in captivity emerged in Dec. (possibly not true to natural conditions here or possibly representing an early summer brood?) The eggs are rain-hatched. (Preserved = 1–6, 9; photos = 1, 2, 5, 5c, 6.)
- *Amelora macarta* Turner (det. IC)—G.151, 151A, 151B, & 151C (under *A. petrochroa* Guest and *A. poliophara* Turner, in some collections). (1) S.AUST., \pm 8 mi. NE of Two Wells, at edge of sandhills (NM & TN): Larvae (20, 27 Aug. 66) only on the twining parasite, *Cassytha pubescens*, which was growing in shrubs of *Calytrix pinculocrata* J. M. Black (dets. MK). Four adults emerged April 67. (Preserved = 1, 4–6, 9; photos = 1, 5c.) (2) S.AUST., Mt. Lofty Range, Belair National Park, $\frac{3}{4}$ –1 mi. E of Belair railway station (NM); also, 4 mi. S of Ashbourne (J. O. Wilson & NM): Larvae (July–Aug. 68) only on *Cassytha pubescens*, which was (in these localities) mostly parasitizing *Leptospermum myrsinoides*, *Casuarina muelleriana*, and *Olearia ramulosa* (dets. NM); also, in one instance, parasitizing *Exocarpos cupressiformis* and harbouring many larvae of *A. macarta*. The last instar larvae show various maculation-phases, one being very strongly marked with 9 or 10 dark, oblique dorso-lateral lines, and the others partially or even totally lacking these prominent marks; all forms were regularly encountered in Belair Nat. Park. Adults emerged March–April 69; univoltine. (Preserved = 1, 5, 6, 9; photos = 1, 5, 6.) (3) W.AUST., \pm 16 mi. N of Geraldton, nr. Oakajee (D. & NM): 2 last instar larvae (28 July 72) on *Cassytha* sp., nr. *glabella* R. Br., which was parasitizing *Casuarina campestris* Diels. (dets. NM). Adults emerged mid-late April 73. This may represent a distinct subspecies. Also common at Drummond Cove, W. A.; larvae on *Cassytha* sp., nr. *pubescens* R. Br., during June and July. (G.151C: Preserved = 1–6, 9.)
- *Amelora milvaria* Gn. (det. IC, NM)—C.114. S.AUST., Blackwood-Belair district (NM): Larvae (July–Sept.) primarily on lvs. of *Pultenaea largiflorens* var. *latifolia*, young lvs. of *Acacia pycnantha*, and mature (tough) lvs. of *Leptospermum myrsinoides*; also (less often) seen feeding on young lvs. of *Acacia myrtifolia* (Sm.) Willd., fls. of *Hakea rugosa* R. Br., foliage of *Exocarpos cupressiformis*, lvs. of *Calytrix tetragona*, young lvs. of **Eucalyptus ficifolia* F. Muell. (in a garden), lvs. of *Olearia ramulosa*, and new lvs.-buds-fls. of **Chrysanthemoides monilifera* (dets. NM). Adults (A) fly mid March–early May. The eggs are rain-hatched. (Preserved = 1–6, 8h, 9; photos = 1, 5c.)
- ?*Amelora* sp. (det. NM)—S.AUST., Mt. Lofty Range, \pm 4 mi. S of Ashbourne (J. O. Wilson): 2 larvae (23 Aug. 68) on the dense-shrubby *Casuarina muelleriana* (det. NM). Adults emerged 4 April (♂), and 6 April 69 (♀). This uncertain determination is included because of the very distinctive adults and the interesting foodplant record; it is hoped that more specimens may eventually be taken. The 2 reared adults are in the A.N.I.C., where the late J. O. Wilson placed his collection before he died in 1972. (Preserved = 1, 6; photos = 1.)

Angelia—see *Loweria*.

• *Boarmia cognata* Walk. (det. IC, SF)—G.91. S.AUST., Blackwood-Belair district (NM): Larvae (most months) common on foliage of the shrubby root-parasite, *Exocarpos cupressiformis* (det. NM). Adults (B+) recorded for every month (peaks in Dec.-Jan. & April). (Preserved = 1, 4-6, 8h, 9; photos = 1, 1c, 2, 5.)

• *Boarmia ?ploxographa* Turner (det. SF, NM)—G.115. (1) S.AUST., Blackwood-Belair district (NM): Larvae (July-Oct.) on many native shrubs, including (particularly) *Pultenaea largiflorens* var. *latifolia* and *Bursaria spinosa* (dets. MK); also seen feeding on young lvs. of *Acacia pycnantha*, *Exocarpos cupressiformis*, *Olearia ramulosa*, and **Chrysanthemoides monilifera* (dets. MK). Adults (A) fly spring-autumn (peak March-April); sexual dimorphism is fairly pronounced. (Preserved = 1, 5, 6, 9; photos = 1, 2.) (2) S.AUST., Hallett Cove, on coastal bluffs S of Adelaide (NM): Larvae (July-Oct.) fairly common on the dominant low-woody shrub, *Beyeria leschenaultii* var. *latifolia* Grüning—EUPHORBIACEAE and the woody shrub, *Alyxia buxifolia* R. Br.—APOCYNACEAE (dets. MK). No adults were reared, so identification is not absolutely certain; these larvae appeared identical to those of the Blackwood population, however. (Preserved = 5, 8hh, 9; photos = 5.)

• *Boarmia penitheatia* Gn. (det. NM)—G.211 (syn. = *rupicolor* Butl.). (1) S. AUST., Blackwood (NM): Captive larvae (March 70) readily accepted young phyllodes of *Acacia pycnantha* (det. NM). Adults (C) fly summer-autumn. First instar larval dispersal is notable in this species. (Preserved = 1-6, 9; photos = 1, 2.) (2) W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (NM): Larvae (spring-summer) on *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). Adults (B) fly most months.

• *Boarmia suasaria* Gn. (det. IC, SF)—G.78. S.AUST., Blackwood-Belair district (NM): Larvae (most months, with a peak in summer) on foliage of *only* the tree, *Casuarina stricta* (det. NM); never found on other (shrubby) *Casuarina* spp. frequently beaten in this locality. Adults (B+) fly Dec.-mid July (peaks Jan. & late March-April). First instar larval dispersal is notable in this species. (Preserved = 1-6, 9; photos = 1, 2, 5.)

• *Boarmia* sp. (det. NM)—G.215. S.AUST., 4 mi. E of Two Wells, Lewiston Park (NM & D. Bakker): Larvae (4 Sept. 69) on the tree, *Callitris preissii* Miq.—CUPRESSACEAE (det. MK). This incomplete determination is included because of the interesting foodplant record; the adult is distinct from all foregoing spp. (Preserved = 1, 5, 6.)

• "*Capusa*" *chionopleura* Turner (det. IC, NM)—G.230. (This unique moth is in no sense referable to *Capusa*, but apparently no other genus is available for it at present; *nor* does it show close kinship with either G.231 or 237.) W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Captive larvae (July-Aug. 72) readily accepted only the (orange) fls. and fl. buds of the leafless intricate shrub, *Daviesia divaricata* Benth.—FABACEAE (det. NM). Adults (D) fly June-July; more common inland, or further north in more arid localities; univoltine. (Preserved = 1-6, 9; photos = 1, 5, 5c, 6.)

• *Capusa senilis* Walk. (det. IC)—G.235. W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Captive larvae (July-Aug.) readily accepted phyllodes of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin); also one record (10 Sept. 76) of a healthy last instar feeding on lvs. of the edible garden pea, **Pisum*—FABACEAE. The latter had probably been on the pea vine all its life, as much evidence of past and recent feeding surrounded the area where it was at rest, and no other possible foodplant was growing anywhere nearby. It was collected and it continued to feed well (for several more days) on the pea leaves, until the pre-pupal wandering stage arrived. *A. ligulata* is undoubtedly the usual foodplant in this locality; new growth is preferred if available. These larvae (and the eggs) show much closer affinities with G.105 than with G.231 or 237; clearly, neither of the latter belong in the same genus with *senilis* and *stenophara*. Adults (B+) fly May-

July (peak late June–early July); univoltine. Regarding adult *Capusa* spp. resting position, see p. 13. (Preserved = 1–6, 9; photos = 1, 5, 5c.)

● *Capusa stenophara* Turner (det. IC)—G.105. (This is a synonym of *cuculoides* Felder according to evidence from genitalic slides prepared and studied by SF, April 71.) (1) S.AUST., Blackwood (NM): Captive larvae (Aug.–Sept.) readily accepted young lvs. of *Eucalyptus odorata*; larvae (in the field) often found on young lvs., fl. buds, and fls. of *Acacia pycnantha*, as well as *Eucalyptus odorata* (dets. NM). Adults (B) fly late May–July (peak mid June); activity primarily from dusk to \pm 2100 hrs (rarely later), often on cold (38–45°F) and clear nights when almost nothing else is on the wing; univoltine. First instar larval dispersal is notable in this species. See McFarland (1972b: 239) for egg photos. (Preserved = 1–6, 9; photos = 1, 2, 5, 5c, 6.) (2) S.AUST., Happy Valley and Aldinga scrub, S of Adelaide (Mr. and Mrs. J. O. Wilson): Larvae (Aug.–Sept. 67) on fl. buds & fls. of *Acacia pycnantha* (det. NM). (3) W.VIC., 5 mi. S of Kiata, Lowan Reserve (NM): Young larvae (28 Sept. 67), of an unidentified *Capusa* sp., beaten from the upright woody shrub, *Melaleuca uncinata* R. Br. ex Ait., in close assoc. with *Baeckea behrii* (Schldl.) FvM.—both MYRTACEAE (dets. MK); the circumstances indicated the former as the probable plant from which these larvae fell.

● “*Capusa*” sp. (det. NM)—G.231 & 231A. (This moth is probably undescribed; it is fairly near *Capusa*, but clearly belongs in another genus; the larvae show closer affinities with G.237 than with typical *Capusa* larvae.) (1) W.AUST., SE of Onslow, at Nanutarra (D. & NM): Original ♀ moth collected at light; eggs obtained. Captive larvae (July–Aug. 72) reared at Drummond Cove, W.AUST., where they readily accepted young phyllodes of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). (Preserved = 1–6, 9.) (2) W.AUST., Drummond Cove, \pm 7 mi. N of Geraldton (D. & NM): Captive larvae (June–July) readily accepted young phyllodes of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). Adults (A) fly late May–early Aug. (peak late June–early July); univoltine. (Preserved = 1–6, 9; photos = 1, 5, 5c.)

● “*Capusa*” sp. (det. NM)—G.237. (This distinctive moth is probably undescribed; it is fairly near *Capusa*, but clearly belongs in another genus; the larvae show closer affinities with G.231 than with typical *Capusa* larvae.) W.AUST., Drummond Cove, \pm 7 mi. N of Geraldton (D. & NM): Captive larvae (mid July–mid Sept.) readily accepted fl. buds & fls. (only) of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin); these larvae are clearly adapted, both in behavior and coloration, specifically to blossom-feeding on acacias. Adults (B–) fly June–July (peak late June). (Preserved = 1–6, 9; photos = 1, 5, 5c.)

● *Casbia lithodora* Meyr. (det. SF, NM)—G.160. (1) S.AUST., Yorke Peninsula, \pm 2 mi. S of Kainton (NM, N. B. Tindale, & P. Aitken): Single larva (4 Nov. 65) on the open-airy shrub, *Pomaderris paniculosa* FvM. ex Reisseck—RHAMNACEAE (det. MK), along with many larvae of G.131; adult ♀ emerged Dec. 65. (Preserved = 1, 6.) (2) S.AUST., at base of Black Hill, Athelstone (Addison Ave.), E of Adelaide (NM & TN): Larvae (22 Oct. 66) common on young and mature lvs. of the woody dwarf shrub, *Cryptandra tomentosa* Lindl.—RHAMNACEAE (det. MK). Adults fly late spring–summer; they are easily alarmed to flight in the daytime (observation of TN, 15 Jan. 67), but are probably not truly diurnal. (Preserved = 1, 4–7, 8h, 9; photos = 1, 5c.) (3) W.AUST., 5 mi. N of Geraldton (Glenfield district), Beatie Rd., Lot 131, in an *Acacia-Banksia* association (D. & NM): One larva (mid Nov. 72) on *Cryptandra* sp. (det. NM); died in last instar (not preserved), but identical to well-marked larvae of the Black Hill population. (SF, in a letter of 8 July 1971, stated that there are “several from Geraldton and one from Perth” in the B.M.(N.H.) series of adult specimens.)

● *Casbia ?rhodina* Turner (det. IC)—G.131. S.AUST., Yorke Pen., \pm 2 mi. S of Kainton (NM, N. B. Tindale, & P. Aitken): Larvae (4 Nov. 65) fairly common on *Pomaderris paniculosa* FvM. ex Reisseck—RHAMNACEAE (det. MK); they match

to perfection (in color and maculation) the undersides of the foodplant lvs. Adults emerged late spring–summer. (Preserved = 1, 5–7, 8h, 9.)

Ceratucha—see *Ciampa*.

“Chlenias”—see also *Ciampa* and “Miscellaneous Unidentified Ennominae” at end of this subfamily.

● *“Chlenias” melanoxysta* Meyr. (det. IC & NM)—G.221 (The type-specimen is *Chlenias melanoxysta* Meyr., in the S. Aust. Museum; an apparent synonym is the oenochromine, *Cycloprorodes apalama* Turner. Clearly, *melanoxysta* does not belong in *Chlenias*.) S.AUST., Belair, at 129 Gloucester Ave.; rarely taken at Blackwood; probably more common between Kalyra Rd. and Windy Point, where *Dodonaea* is abundant (?) (D. & NM): Captive larvae (June–July 71) readily accepted lvs. of (only) *Dodonaea viscosa* (det. NM), esp. the new growth. These larvae are difficult to rear, needing abundant daily moisture combined with excellent ventilation and low temperatures. They show not the remotest kinship with *Chlenias* larvae. Adults (C) fly only mid May–mid June (peak late May); univoltine. The eggs seem to be on the borderline of a rain-hatching tendency. (Preserved = 1–4, 6, 9; photos = 1, 1c, 2, 5.)

● *Chlenias ?pachymela* Lower (det. NM)—G.106 & 106A. S.AUST., Blackwood-Belair district (NM): Larvae (July–Oct.) on a wide range of native and introduced woody plants, some specific examples being: *Bursaria spinosa*, *Dodonaea viscosa*, young lvs. of *Acacia pycnantha*, *Pultenaea largiflorens* var. *latifolia*; one record on a plum tree, **Prunus* sp., and one on young lvs. of loquat, **Eriobotrya* sp.—both ROASACEAE; and one feeding well on fl. buds of **Camellia* sp.—THEACEAE (dets. NM). Of the native flora in this locality, the first 3 plants listed appear to be preferred, particularly *Bursaria*. These larvae always have a distinctive raspberry-erred blotch (which fades out completely in alcohol) near the base of the A6 proleg; the head is notably bulbous, light golden-brown, and only faintly-marked. Disturbed fullgrown larvae are usually reluctant to release hold or drop; if dropping, usually on a tough silk thread. Adults (B+) fly mid May–July, and are the largest (and “heaviest”) of the *Chlenias* spp. in this locality; univoltine. The eggs are rain-hatched. (Preserved = 1–7, 9; photos = 1.)

● *“Chlenias” rhynchophora* Lower (det. SF, NM)—G.127 & 127A. (The ♀ type specimen is *Chlenias rhynchophora* Lower, in the S.Aust. Museum. This moth clearly has no kinship with *Chlenias*; it appears to belong in the genus *Rhynchopsota*.) S.AUST., Belair Nat. Park, 1 mi. E of Belair railway station; also the Eden Hills-Blackwood district (NM & TN; G. Furness): In the first locality larvae (Oct.–early March) are mostly on the locally-abundant shrub, *Casuarina muelleriana*, but also on the tree, *C. stricta* (dets. MK). In the two latter localities, they are mostly on *C. stricta*, as *C. muelleriana* is extremely rare here. There is a major population of this sp. below 5 Yalanda St., Eden Hills. In common with a number of Australian oenochromine genera (many *Dichromodes* spp., *Monoctenia*, and *Phallaria* are examples), the larval growth-rate in *rhynchophora* is very slow under natural conditions; interestingly, they are on the plants throughout the hottest and driest months of the year (Nov.–March), a time when most univoltine spp. are in pupal diapause here. The eggs take 6–7 weeks to hatch, and the larval stage lasts a full 8 months (about mid July–mid March)! This is altogether an aberrant species in several respects. The larvae (also the eggs and pupae) show no affinities with *Chlenias* spp., but do appear to be fairly close to the *Dichromodes* larval type with regard to general appearance, profile, growth-rate, habits, and behavior. Adults (A, nr. 5 Yalanda St., Eden Hills; B±, in most parts of Blackwood) fly mid May–mid July (peak only late May–mid June); univoltine. See McFarland (1972b: 237) for egg photo. (Preserved = 1–6, 9; photos = 1, 2, 4–6.)

● *Chlenias seminigra* Rosenstock (det. NM)—(G.220 ?). S.AUST., Mt. Lofty Range, Aldgate (Heather Rd.) (NM & D. Bakker): (a) Mature larva coll. by K. Sandery (Sept. 70) on the parasitic twiner, *Cassytha* sp. (det. K. Sandery); ♂ adult emerged 1 June 71. (b) Mature larva (13 Sept. 69) on fl. buds and fls.

of the dwarf shrub, *Dillwynia hispida* (det. NM). I suspect that the single larva collected by Sandery (a), which I never saw, and my single larva (b), for which no adult was reared, are one and the same species. The fullgrown larva (b), my G.220, is deposited in the S. Aust. Museum, and the reared adult (a) is in the K. J. Sandery collection. The G.220 larva shows strong affinities with my G.111, but is somewhat larger and is more extensively and colorfully-marked. These incomplete records are included because of the apparent rarity (or very localized occurrence) of *C. seminigra* in this part of South Australia. The dark brown to sooty-tinged adult is quite unlike any other *Chlenias* here discussed. Probably univoltine. (Preserved = ♂ 1, (5♀), 6; photos = ♂ 1.)

• *Chlenias* sp., near *stenosticha* Turner (det. IC, NM)—G.111, 111A, & 239. (1) S.AUST., Blackwood-Belair district (NM): Larvae conspicuous (July–Sept.) on fl. buds, fls., and young growth of various native woody shrubs, esp. *Cryptandra tomentosa* Lindl.—RHAMNACEAE and *Grevillea lavandulacea*; sometimes on buds of *Dillwynia hispida* and young lvs. of *Calytrix tetragona* (dets. MK). These larvae appear to be primarily bud and flower feeders in this locality, if allowed their preference. Very colorful: among the distinctive markings are two intense reddish-brown lateral spots, one each on T2 and T3, just above the broad and prominent yellow-cream spiracular line, which extends the full length of the body. Fullgrown larvae are quick to curl up and fall free (never on a silk thread) if disturbed. Adults (B–) fly April–May (univoltine); they are rather frail when compared to other *Chlenias* spp. occurring here, and are the smallest sp. around Blackwood; although uncommon at my lights, the larvae of this sp. were more frequently encountered here (1965–1970) than were those of G.112. (Preserved = 1–6, 9; photos = 1, 5.) (2) S.AUST., nr. Hallett Cove railway station (NM): 2 small larvae (6 Aug. 67) on fl. buds and fls. of *Acacia rotundifolia* Hook. (det. NM). (3) W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Captive larvae (June–early Aug. 73) readily accepted new and semi-mature phyllodes of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). Growth was rapid and disease-free on this plant. Although initially code-numbered G.239, it became evident by last instar that these larvae merely represented a western population of my South Australian G.111 material. (Preserved = 1–6, 9.) (4) W.AUST., in Spalding Park, Bluff Point district, N of Geraldton (D. & NM): Larvae (July, 1973) on fls. and new lvs. of *Grevillea pinaster* Meisn. (det. WAH). (Preserved = 5.)

• *Chlenias* ?*umbraticaria* Gn. (det. SF, NM)—G.112. (1) S.AUST., Blackwood-Belair district (NM): Larvae conspicuous (July–Sept.) on fl. buds, fls., and young growth of various native woody shrubs, quite often in association with larvae of the foregoing sp. (G.111). Favoured foodplants here are fls. of *Hakea rostrata* and fls. of *Cryptandra tomentosa* Lindl.—RHAMNACEAE; also (less often) on fls. of *Grevillea lavandulacea*, fls. of *Pultenaea largiflorens* var. *latifolia*, or on *Cassytha pubescens* (dets. MK). Fullgrown larvae of this moth are similar, in both habits and behavior, to those of G.111, but are entirely different in details of color-maculation; they are also “heavier” (more massive) in the whole body. Very colorful: some of the distinctive marking are about 10 well-separated brick-red (or orange-brown) elongate lateral marks, one per segment, on the white spiracular line (from T2–A8); dorsum and sides (above spiracular line) entirely without other major stripes, the whole area being reticulate-speckled in a pattern of dark gray-brown rings, surrounding whitish dots, which creates an overall effect of being heavily and uniformly “salted” on a dark background. Adults (B) fly late March–April (univoltine); they are quite unlike any of the other *Chlenias* spp. here listed, and (atypically for this genus) show only minor individual variation in color and maculation. The eggs are rain-hatched. (Preserved = 1–6, 8h, 9; photos = 1, 2, 5, 5c, 6.) (2) W.AUST., ± 5 mi. N of Geraldton (Glenfield dist.), along Beatie Rd. (D. & NM): One larva (20 July 73), of what is almost certainly this sp., found among low shrubs at roadside, resting in full view, head downward; foodplant unidentified. (Preserved = 5.)

• *Chlenias* sp. nov., near *banksiaria* LeGuill. (det. SF)—G.103, 103A & 103B. S. AUST., Blackwood-Belair district and Hallett Cove (NM): Larvae (June–Sept.) on several native woody shrubs; by far the preferred foodplant (of the Blackwood population) appears to be *Olearia ramulosa*, which bushes they nearly defoliated in some years during the winter (along Hannaford Rd.); they were often abundant on both *Dodonaea viscosa* and *O. ramulosa* at Windy Point (Belair); along Gloucester Ave. (Belair), and in parts of Blackwood, they were sometimes common on *Bursaria spinosa*; occasionally also on **Chrysanthemoides monilifera* and **Genista maderensis* (dets. NM). At Hallett Cove, I found them only on *Olearia ramulosa* (fairly common, but never in the great numbers sometimes seen at Blackwood). Although colorful, they blend in fairly well with the “intricate confusion” of shadows and thin (linear) *O. ramulosa* lvs.; the overall pattern on the larva (dorsolaterally) is of many fine parallel lines of black, white, and yellow to orange. The single strong middorsal line is pale to deep orange in living larvae of this species, and on that alone it is separated from all other *Chlenias* spp. listed here, except G.188. (Head notably less bulbous than in G.188 or G.106, and strongly-marked with dark brown longitudinal lines on a pale pinkish-tan ground color.) Disturbed fullgrown larvae are quick to curl inward; if dropping from the plant they fall free, never on a silk thread. Adults (A) fly March–July (peak June); univoltine. (Preserved = 1–6, 8hh, 9; photos = 1, 5, 5c, 6.)

• *Chlenias* sp. nov. (det. SF)—G.120. S.AUST., Blackwood (NM): Larvae scarce (Sept. 65) on *Pultenaea largiflorens* var. *latifolia* (only); readily accepted young lvs. of *Acacia pycnantha* as a substitute (dets. NM): These *Chlenias* larvae show a confusing mixture of the characteristics of my G.106 and G.103, with respect to color, maculation, morphology, and behavior. The few adults seen were hard to separate from G.106, but slightly smaller. Could this be a natural hybrid of G.103 \times G.106? (Preserved = 1, 5, 6, 9.)

• *Chlenias* sp. nov. (det. SF)—G.148. S.AUST., \pm 8 mi. NE of Two Wells, at edges of sandhills (NM & TN): Larvae (20 Aug. 66) abundant on oldman saltbush, *Rhagodia parabolica* R. Br.—CHENOPODIACEAE (det. MK) which is apparently the preferred foodplant of this population; also encountered, in far lower numbers on a few other unrelated native woody plants in this and nearby localities. In general appearance, maculation, and behavior, these larvae show strong affinities with my G.103, but are easily separated and almost certainly another species (or a subspecies at the least). Two adults emerged: 9 May 67 (δ) and 13 May 67 (η); probably univoltine. (Preserved = 1, 4, 5, 6, 9; photos = 1.)

• *Chlenias* sp. nov. (det. SF)—G.188 & 188A. (1) W.VIC., 5 mi. S of Kiata, Lowan Reserve, nr. the designated camping area (NM): Larvae (28 Sept. 67) on the woody shrub, *Baeckea behrii* (Schldl.) FvM.—MYRTACEAE (det. MK). These larvae are very colorful and fairly conspicuous on the foodplants; general appearance (build), bulbous head, and behavior show affinities with my G.106. All colors and markings on these larvae are gaudy, rich, and intense—more so than in any of the other *Chlenias* larvae here listed (with the possible exceptions of G.111 and G.220, which look nothing like this one). Two distinctive features: the true legs are vivid reddish-purple, and there are 6 black dots in a semi-circle directly behind the head (cervical area). (Preserved = 5, 8h, 9.) (2) S.AUST., 1.2 mi. S of Monarto South railway crossing, \pm 10 mi. W of Murray Bridge (NM & TN): Larvae fairly common (8 Oct. 67) on *Baeckea behrii* (det. NM). Two δ adults emerged: 19, 21 May 68; probably univoltine. (Preserved = δ 1, 6, 9; photos = 1 δ .)

• *Chlenias* sp. (det. NM)—G.206 & 206A. (1) W.AUST., 13 mi. E of Tambellup (NM & N. B. Tindale): Larvae (21 Nov. 68) on a woody shrub, *Melaleuca uncinata* R. Br. ex Ait.—MYRTACEAE (det. NM). (Preserved = 5, 6.) (2) W.AUST., at Wave Rock, nr. Hyden (D. & NM): Larvae (28 Oct. 71) common on a tall *Leptospermum* sp. (det. NM); the foodplant was growing abundantly around the parking area (nr. base of Wave Rock) and was in bloom on this date (petals pinkish-tinged white). These larvae show affinities with my G.106, and even more

with G.188, but are quite distinct. Pupae were obtained but all died later; no adults have been seen thus far, but the distinctive larvae are clearly different from all the foregoing spp. and warrant mention here. Probably univoltine.

General remarks on the foregoing *Chlenias* spp. (with the exception of G.127 and G.221, which probably belong in the Oenochrominae): The several incomplete determinations are included here primarily because of the excellent and consistent larval differences and the diverse (but sometimes specific) foodplant preferences; these records could be of great immediate assistance to future workers attempting to study this difficult genus. It took me 5 years and countless field-trips to gather the information here recorded, all of which is documented by extensive notes, preserved larvae and pupae, and the associated reared adults; these have been deposited in the institutions listed in the Introduction. The adults are (in most of the spp.) of rather similar appearance, somewhat variable, and often tend to overlap in certain features of the maculation. They are regularly and thoroughly mixed up in most collections!

Most *Chlenias* larvae make little or no attempt to hide by day and are not cryptically-colored—thus usually conspicuous on their foodplants. Good differences (and affinities) can be seen in the larval head capsules of the various species. Eggs were not obtained from 5 of the above spp., so little can be said here of their comparative or taxonomic value. The eggs would certainly warrant close examination in any future study of this complex and fascinating genus, which is so well-represented across southern Australia.

● *Ciampa arietaria* (Gn.) (det. IC)—G.93. (1) S.AUST., Adelaide city suburbs; also Blackwood-Belair district (NM): The rather noctuidiform larvae (June–Aug.) are often locally abundant on the weedy South African annual, **Arctotheca calendula* (det. NM). It would be interesting to know what was the primary foodplant here prior to the introduction of the now exceedingly abundant Cape weed; this moth may have been considerably less abundant long ago. Adults (A+) fly mid March–early June; univoltine. The eggs are rain-hatched. See Common (1966b: 81 and 1970: 844) for ♂ adult photos. (Preserved = 1–6, 9; photos = 1, 2, 5.) (2) W. AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. NNE of Geraldton (see McFarland, 1977): One last instar larva (26 Aug. 78) feeding on inflorescence of **Zaluzianskya divaricata* (Thunb.) Walp.—SCROPHULARIACEAE (det. NM), at edge of paddock S of Zone 4 (NM & Lisa Green). This sp. also comes commonly to uv. light at Drummond Cove, ± 7 mi. N of Geraldton, W. Aust., (± mid April–July).

● *Cleora bitaeniaria* (LeGuillou) (det. IC)—G.86. S.AUST., Blackwood (NM): Captive larvae (April–May) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM); larvae are probably present on eucalypts during most months of the year in this locality. Adults (B+) recorded for every month (peaks Sept., Dec., & Feb.–June). See McFarland (1972b: 239, 245) for egg photos. (Preserved = 1–6, 9; photos = 1, 1c, 2, 5, 6.)

● *Cleora displicata* Walk. (det. SF)—G.165. (1) S.AUST., Blackwood (NM): Captive larvae (March) readily accepted young lvs. of *Acacia pycnantha* (det. NM). Adults (B) fly Oct.–April (peak Jan.–March). First instar larval dispersal is notable in this species. See McFarland (1972b: 239) for egg photos. (Preserved = 1–6, 9; photos = 1, 2, 6.) (2) S.AUST., 4 & 5 mi. E of Two Wells, at Lewiston Park and along roadside (NM & TN): Larvae (19 March 67), of what is probably this sp., fairly common on *Acacia salicina* Lindl., *A. ligulata* A. Cunn. ex Benth. and *Cassia nemophila* Cunn. ex Vogel—MIMOSACEAE & CAESALPINIACEAE (dets. MK).

● "*Cleora*" *repetita* Butl. (det. IC)—N.QLD., 14 mi. N of Cairns, at Clifton Beach (D. & NM): Larva (9 May 72) on buds, fls., and lvs. of the shrub, *Fenzlia obtusa* Endl.—MYRTACEAE (det. BH). The adult (a large ♀) emerged 19 June 72; deposited in A.N.I.C., Canberra. (Preserved = 1, 6.)

● *Corula geometroides* Walk. (det. SF)—G.170 & 170A. (1) S.AUST., ± 4 mi. E of Two Wells, Lewiston Park (NM & TN; NM & C. N. Smithers): Larvae (19 March

67; 4 May 67; Sept.-Oct. 69) on native "pine," *Callitris preissii* Miq.—CUPRESSACEAE (det. MK); regularly obtained by beating. Probably multiple-brooded; some adults emerged Jan.-Feb. 1970. (Preserved = 1, 4-6, 9; photos = 1, 5, 6.) (2) VIC., Grampians Mts., S of Hall's Gap, at Mirrantawa Gap (NM & E. C. Jaeger): Larvae (26 Sept. 67) on *Callitris rhomboidea* R. Br. ex Rich. (det. MK). (Preserved = 5, 8h.)

Criomacha—see *Fisera*.

• "*Diastictis*" *goniota* Lower (det. NM)—G.214. S.AUST., Hallett Cove, S of Adelaide (D. & NM): Larvae (2 June 71) abundant on the woody, perennial vine (not a parasite), *Muehlenbeckia gunnii* (Hook. f.) Walp.—POLYGONACEAE, which was growing in tangles over shrubs of *Olearia axillaris* (DC.) FvM (dets. NM), just back from the beach. This tentative record has yet to be positively verified by reared adults, but is probably correct; it is included here because of the distinctive foodplant which might provide a useful clue toward further investigations of this moth. The generic placement is doubtful, but the type of *goniota* is in the S. Aust. Museum (Adelaide). Adults fly (?) July-Sept.; probably univoltine. (Preserved = 1-5, 9; photos = 1.)

• *Didymoctenia exsuperata* Walk. (det. SF)—G.122. S.AUST., Blackwood (NM): Captive larvae (Sept.-Oct.) readily accepted young lvs. of *Eucalyptus odorata* (det. NM); larvae are probably present on young lvs. of eucalypts during most months of the year in this locality. Adults (A) fly Sept.-July (peaks Oct.-Dec. & May-June) with by far the majority coming to uv. light only after 2300 hrs. (Preserved = 1-7, 9; photos = 1, 2.)

• *Ectropis excursaria* (Gn.) (det. IC, SF)—G.75, 75A, 75B, & 75C. (1) S.AUST., N Adelaide city parklands (NM): Larvae (Jan.-Feb. 65) common on tender young sucker-growth at the base of an old pepper tree, **Schinus molle* L.—ANACARDIACEAE (det. NM). (2) S.AUST., Belair (F. J. Mitchell): Larvae (Aug.-Oct.) abundant on young and semi-mature lvs. of the perennial native vine, *Hardenbergia violacea* (det. NM); almost defoliating this plant which was being grown against a garden wall. (3) S.AUST., Blackwood-Belair-Eden Hills district (NM): Larvae (spring-autumn) on numerous unrelated woody and herbaceous plants (both native and introduced). Some specific records: In gardens on an ornamental ivy, **Hedera* sp.—ARALIACEAE; **Pelargonium* sp.—GERANIACEAE; orange tree (young lvs. of sucker-growth), **Citrus*—RUTACEAE; **Polygonum aviculare* L.—POLYGONACEAE; young lvs. of **Eucalyptus cladocalyx* FvM; also (in the natural scrub) often on *Pultenaea largiflorens* var. *latifolia*, new lvs. of *Acacia pycnantha*, *Exocarpos cupressiformis*, *Bursaria spinosa*, and etc. (dets. NM). Adults (B+) fly all months (peaks Sept.-Oct., April-June); sexual dimorphism is evident. First instar larval dispersal is notable in this species. (Preserved = 1, 2, 5, 6, 8h, 9; photos = 1, 2, 5, 6.) (4) S.AUST., 5 mi. E of Two Wells, along roadside (NM & TN): Larvae (19 March 67) fairly common on *Acacia ligulata* A. Cunn. ex Benth. and *Cassia nemophila* Cunn. ex Vogel—MIMOSACEAE & CAESALPINIACEAE (dets. MK). (5) W.AUST., Perth, in the California Section of the Botanic Gardens at King's Park (D. & NM): Larvae (16 Oct. 72), probably of this sp., feeding (and thriving) on California sagebrush, **Artemisia californica* Less.—ASTERACEAE and also on deerweed, **Lotus scoparius* (Nutt. in T. & G.) Ottley—FABACEAE (dets. NM); both of these plants are abundant natives in the sage scrub and chaparral (evergreen sclerophyll) associations of southern California, at lower elevations near the coast.

• *Ectropis odontocrossa* Turner (det. NM)—G.153. S.AUST., ± 8 mi. NE of Two Wells, on white sandhills (NM & TN): Larvae (27 Aug. 66) common on the woody shrubs, *Bertya mitchellii* (Sond.) Arg.—EUPHORBIACEAE and *Dodonaea bursariifolia* FvM. (dets. MK), but not found on any other shrubs beaten in this habitat. A ♂ adult emerged 9 June 67. (Preserved = 1, 4-6, 9; photos = 1, 5c.)

• *Ectropis pristis* Meyr. (det. NM)—W.VIC., 5 mi. S of Kiata, at the Lowan Reserve (Sanctuary), nr. the designated camping area (NM): Larvae (28 Sept. 67)

on *Baeckea behrii* (Schldl.) FvM.—MYRTACEAE (det. MK). ♂ and ♀ adults emerged, but hatching-date was not recorded. (Preserved = 1, 6.)

• *Ectropis* sp., close to *aganopa* Meyr. (det. IC)—(1) S.AUST., Yorke Peninsula, nr. S end of Formby Bay (NM, N. B. Tindale & P. Aitken): Larva (2 Nov. 65) on *Acacia calamifolia* Sweet ex Lindl. (det. MK). A ♂ adult emerged late Nov. 65. (Preserved = 1, 6.) (2) S.AUST., ± 4 mi. S of Ashbourne (J. O. Wilson): Larva (31 March 69) beaten from the twining parasite, *Cassytha pubescens* (det. J. O. Wilson). An adult emerged 3 May 69; in Wilson Collection, A.N.I.C., Canberra.

Fisera—see also remarks under *Mnesampela fucata* and *Stathmorrhopa macroptila*.

• *Fisera eribola* (Guest) (det. IC)—G.90 (possibly synonymous with *Mnesampela dictyodes* Lower). S.AUST., Blackwood (NM): Captive larvae (May–July) readily accepted mature lvs. of *Eucalyptus odorata* and *E. leucoxylon* (dets. NM). Adults (A) fly late Feb.–mid May (peak late March–early April); univoltine. They come to uv. light mostly after 2300 hrs. Only minor individual variation is shown in color and maculation. The eggs seem to be on the borderline of a rain-hatching tendency, and first instar larval dispersal occurs. The adult rests in the manner of *S. macroptila* (p. 32). (Preserved = 1–6, 9; photos = 1, 1c, 2, 4, 5, 5c.)

• *Fisera perplexata* Walk. (det. IC)—G.95 (possibly synonymous with *belidearia* Felder). S. AUST., Blackwood (NM): Larvae (July–Oct.) on mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B+) fly April–July. There may possibly be two distinct spp. involved here, although I suspect it is one moth with highly variable coloration. Three major color-maculation forms (with minor variations in each) occur consistently in the Blackwood-Belair district: (a) the earliest form to appear (April–May) has a pale tan forewing groundcolor with a prominent (darker brown) single discal dot, a fairly strong, darker brown postmedial line, and little or no speckling; (b) the next form(s) to appear (from about early May onward) are generally more-or-less heavily-speckled with darker brown, on medium brown to orange-brown or gray-brown groundcolor, and the postmedial line is non-existent or very faint; (c) the last form to appear (from about early June onward) is often a little larger and very much darker in groundcolor, which can be a deep but dull reddish- or almost purplish-brown, with little or no evidence of either the post-medial line or the heavy speckling, although a single discal dot may (or may not) be present. The flight seasons of forms (a) and (b) overlap (early–late autumn), as do forms (b) and (c), but (a) and (c) are well-separated. Further rearings, from known females of all three major forms, all from the same locality, could provide the information needed for a deeper understanding of this (or these) interesting and perplexing species! The eggs are rain-hatched. (Preserved = 1–7, 9; photos = 1 for all forms, 2 & 5 of earliest form only.)

Gastrinodes—see *Cleora*.

• *Gastrinopa xylistis* Lower (det. NM)—G.137. S.AUST., Blackwood (NM): Captive larvae (Nov.–Jan.) readily accepted only young lvs. of *Eucalyptus odorata* (det. NM). Adults (B+) fly Sept.–Feb. (peak Oct.–Dec.). First instar larval dispersal is notable in this species. (Preserved = 1–7, 9; photos = 1, 2, 5, 6.)

• *Heteroptila argoplaca* (Meyr.) (det. SF, IC)—G.108A. S.AUST., Blackwood (NM): Captive larvae (most months) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM). Adults (A) fly all months (peaks Feb.–March & May–June). (Preserved = 1–6, 9; photos = 1, 2.)

• *Idiodes apicata* Gn. (det. SF, IC)—G.147, 147A, & 147B. (1) S.AUST., Blackwood-Belair district, Highbury (E of Adelaide), and Naracoorte (TN, D. & NM, and K. J. Sandery): Larvae (most months, esp. winter–spring) on both young and old (tough) fronds of bracken-fern, *Pteridium esculentum* (det. Hj. Eichler). This is apparently the only foodplant of this moth; but see also *Metrocampa*. Adults (B) fly all months (peak June–Oct.). See Tillyard (1926: Pl. 39) for adult photo; McFarland (1972b: 237, 246) for egg photos. (Preserved = 1, 2, 5, 6, 9; photos = 1, 1c, 2.) (2) N.QLD., Atherton Tableland (± 2500' el.), nr. Tinaroo (D. & NM): Larvae (April–May 72) on *Pteridium esculentum*; also evidence of earlier feeding on

P. ?aquilinum (L.). Kuhn (dets. BH) but no larvae found. This latter bracken is of somewhat taller and more rank growth, and has notably pubescent stems in this locality. (Both plants are growing together here.) Captive larvae readily accepted both, but appeared to prefer *P. esculentum*. (Preserved = 1-6, 9.)

• *Lophothalaina habrocosma* (Lower) (det. NM)—G.154, 154A, & 154B. S.AUST., Mt. Lofty Range, Belair Nat. Park, ± 1 mi. E of Belair railway station, just S of Sheoak Rd.; also 4 mi. S of Ashbourne (J. O. Wilson), and nr. Longwood (NM & TN): Larvae (June-Sept.) on old, mature (sclerophyll) lvs. of *Leptospermum myrsinoides* (det. NM). Adults (D, at Blackwood) recorded only for mid April 67; probably more abundant at the above-named specific localities, in close association with the foodplant (a "frail" moth and a weak flyer). Emergences in captivity were all in March or April (strictly univoltine). The J. O. Wilson Collection, now in A.N.I.C. (Canberra), contains a good series of reared adults, most of which are from larvae I collected at the above Belair locality in July-Aug. 68, a winter in which larvae were very abundant there. The eggs seem to be on the borderline of a rain-hatching tendency. See McFarland (1972b: 241) for egg photos. See p. 13 regarding adult resting-position. (Preserved = 1-7, 9; photos = 1, 2, 5, 5c, 6.)

• *Loweria platydesma* (Lower) (det. IC, NM)—G.152. S.AUST., ± 5 mi. E of Two Wells (± 25 mi. N of Adelaide) (NM & TN): Larvae (27 Aug. 66) common, in a restricted roadside strip, on buds, fls., and mature lvs. of *Cassia nemophila* Cunn. ex Vogel—CAESALPINIACEAE (det. MK). Adults emerged mid April 67 (3 δ δ , 1 ϕ); these 4 specimens show tremendous variation in the darker maculation of the forewings, but not in the grayish groundcolor. Probably univoltine. (Preserved = 1, 5, 6, 8h, 9; photos = 1.)

• *Melanodes anthracitaria* Gn. (det. NM)—G.161. S.AUST., Blackwood-Upper Sturt district (NM): Captive larvae (Nov.-Dec.) readily accepted only young lvs. of *Eucalyptus odorata* (det. NM); no doubt feeds on many other *Eucalyptus* spp. as well. Adults (B, at Blackwood) fly mid Sept.-Dec. (peak Nov.); they are more abundant around Upper Sturt; univoltine. First instar larval dispersal is notable in this species. See Common (1970: 849, fig. D) for a line drawing of the pupa. See McFarland (1972b: 241) for egg photos. (Preserved = 1-7, 9; photos = 1, 1c, 2, 5, 5c, 6.)

• *Metrocampa ada* (Butl.) (det. IC)—G.136. S.AUST., Naracoorte, 13 Lochiel Ave. (TN): Larvae (July-Aug.) common on mature lvs. of bracken, *Pteridium esculentum* (det. Hj. Eichler). These larvae are quickly separated from the two other South Australian bracken-feeding geometrids (*Idiodes apicata* and *Metrocampa biplaga*) by their much smaller size when fullgrown, and by the strong, dark brown, dorsal chevron markings (= "herring-bone" maculation). Like *M. biplaga*, the larvae of *ada* are notably sluggish in behavior, in contrast to the active larvae of *Idiodes*. (Preserved = deformed 1, 5, 6, 8h, 9; photos = 5.)

• *Metrocampa biplaga* Walk. (det. NM)—G.217 & 217A—(possibly synonymous with *glaucias* Walk.). (1) S.AUST., Naracoorte, 13 Lochiel Ave. (TN): Larvae (July-Aug.) on older (tough) lvs. of *Pteridium esculentum* (det. Hj. Eichler). These larvae, when filled out in last instar, are large and rather "heavy" in build, and are notably sedentary in behavior; these two characteristics alone will quickly separate them from larvae of the more common *Idiodes apicata* (my G.147) which also occur on the same foodplant, often together with larvae of both *Metrocampa* spp. Adults fly March-April (little data available for Naracoorte). (Preserved = 5, 6, 9; photos = 5, 6.) (2) S.AUST., Belair Nat. Park, nr. Long Gully (NM): Larvae (Sept.-Oct. 69) of *M. biplaga* in company with larvae of *I. apicata*, both feeding primarily on the older lvs. of *P. esculentum*. *Idiodes* was more abundant at the time. (Preserved = 1, 2, 9; photos = δ 1 from Aldinga, S. Aust.)

Mnesampela—see also *Fisera*.

• *Mnesampela fucata* (Felder) (det. NM)—G.109. S.AUST., Blackwood (NM): Larvae (June-Aug.) on mature (tough) lvs. of *Eucalyptus odorata* (det. NM); the unique last instar larva rests outstretched on a strong silken mat, usually on the

upper (or more exposed) surface of a leaf, always aligned \pm parallel to the midrib, in a manner reminiscent of many *Papilio* larvae. (The same habits are also seen in the mature larvae of *Fisera eribola* and *F. perplexata*, but the *perplexata* larva is more often inclined to rest on a leaf margin, especially when smaller.) Adults (A+) fly mid March–late June (peak mid April–May), with predominantly ♂♂ coming to uv. light in the earlier part of the flight season and ♀♀ mostly appearing from May onward; ♂♂ to light mostly after 2300 hrs, and ♀♀ mostly before that time; univoltine. The adult forewing shows considerable variation in 2 features: (1) The groundcolor can vary from pale cream (fresh, unfaded ♂♂ only), to light golden-tan (♂♀), to deep tan with a faint pinkish tinge (♀♀ only), to rich rust or orange-brown (♀♀ only); (2) the degree of speckling (small darker dots) can vary from heavy and intense to nil, and is primarily a feature of the ♀♀. The eggs are rain-hatched and first instar larval dispersal is notable. This species provides a splendid example to illustrate both of these phenomena, which are described at some length in an earlier paper (McFarland, 1973). See McFarland (1972b: 239) for egg photos. (Preserved = 1–7, 9; photos = 1, 2, 5, 5c.)

• *Mnesampela lenaea* Meyr. (det. IC)—G.118 & 118A (probably synonymous with *comarcha* Meyr.). (1) S.AUST., Blackwood (NM): Larvae (July–Sept.) usually on saplings (eating only old lvs.) of *Eucalyptus odorata* or *E. leucoxylon*. I also have one record (10 Sept. 66), of a single last instar larva thriving on **E. ficifolia* F. Muell. (W. Aust. native) in a Blackwood garden; this larva had a deep reddish-pink groundcolor, and was eating only the young (red) lvs. of that highly sclerophyll eucalypt (dets. NM). These larvae are semi-gregarious when small, but unlike *M. privata* have no nest-building habit whatsoever in any of the instars; usually solitary when fullgrown. They tend to sit exposed on brown or tan (dead) parts of partially-damaged lvs. in full view, but they are well protected by their close resemblance to brown bits of dead and curled leaf. Adults (B+) fly late March–June (peak May); univoltine. The eggs are rain-hatched. (Preserved = 1–7, 9; photos = 1, 2, 5, 5c, 6.) (2) S.AUST., nr. Mt. Lofty Summit (Cleland Park): Larva (19 Aug. 69) on mature lvs. of a *Eucalyptus viminalis* sapling (det. MK). (3) S.AUST., Kangaroo Island, 10 mi. W of Vivonne Bay (NM): Larva (3 Sept. 67) on one of the mallee eucalypts, *E. diversifolia* Bonpl. (det. MK).

• *Mnesampela privata* (Gn.) (det. IC)—G.82. S.AUST., Blackwood (NM): Larvae (May–July) often conspicuous when defoliating small saplings, especially stunted or “struggling” individuals (eating old, mature lvs.) of *Eucalyptus odorata* and *E. leucoxylon* (det. NM). The larval habits are unusual in the Geometridae, as they are semi-gregarious even when fullgrown, more so when smaller; they make tough silk nests in partially-curved lvs., in which several rest (half-curved and close together) by day, coming out to feed on nearby foliage after dark. Adults (A) fly late Feb.–May (peak April); univoltine. See Common (1966b: 83) for a ♂ adult photo; Common (1970: 849, fig. A) for a line drawing of the final instar larva. (Preserved = 1–7, 8hh, 9; photos = 1, 5, 6.)

• *Niceteria macrocosma* (Lower) (det. NM)—G.200. S.AUST., Blackwood (NM): Captive larvae (April–June) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B–) fly Feb.–early April, mostly coming to uv. light after 2300 hrs (even by 0300–0400 hrs they are still coming in); univoltine. This is one of the largest and most colorful geometrids occurring here. See Common (1966b: 72) for a good watercolor painting of the adult. See McFarland (1972b: 241) for egg photo. (Preserved = 1–7, 9; photos = 1, 1c, 2, 4, 5, 5c, 6.)

• *Osteodes ?fictilaria* (Gn.) (det. IC)—G.107. S.AUST., Blackwood (NM): Larvae (March–July–?) on *Dodonaea viscosa* Jacq.—SAPINDACEAE (det. NM). Adults (B) fly March–May–? Probably univoltine. (Preserved = 1, 2, 4–6, 8h, 9; photos = 1, 2, 5.)

Paralaea—see *Fisera*, *Mnesampela*, *Stathmorrhopa*.

Paramelora—see “*Diastictis*” *goniota*.

Parosteodes—see *Osteodes*.

"*Protamelora*" (Aust. Museum, Sydney)—see "*Diastictis*" *goniota*.

"*Pseudopanthera*"—see *Lophothalaina*.

Rhynchopsota—see "*Chlenias*" *rhyncophora* Lower.

• *Smyriodes aplectaria* Gn., 1857 (det. SF)—G.140 & 140A (possibly synonymous with *notodontaria* Walk., 1860). (1) S.AUST., Blackwood-Belair district (NM): Larvae (Aug.–Oct.) are primarily fl. and fl. bud-feeders (if allowed their preference), but will also eat the young lvs. of some of the plants involved. Around Blackwood, by far the preferred foodplant appears to be *Pultenaea largiflorens* var. *latifolia*; they also readily accepted young lvs. of *Acacia pycnantha* (dets. NM) in captivity, but I have no field records of larvae on the latter. In Belair Nat. Park (just S of Sheoak Rd.), I have found them feeding (in about equal numbers) on 3 unrelated plants: *P. largiflorens latifolia*; buds & fls. of the parasitic twiner, *Cassytha pubescens*; swelling fl. buds of *Leptospermum myrsinoides* (dets. NM). Adults (B) fly mid May–mid July (peak very short, only late May–early June), and they come to uv. light primarily after 2300 hrs, which may explain their relative scarcity in collections; univoltine. The eggs are rain-hatched. (Preserved = 1–7, 9; photos = 1–5, 5c, 6.) (2) S.AUST., Black Hill, at end of Addison Ave., Athelstone, E of Adelaide (TN): Several larvae (Aug.–Sept. 67) beaten from *Cassytha pubescens* which was parasitizing the shrubby *Casuarina muelleriana* (dets. TN); the larvae were definitely eating the *Cassytha*, not its host, according to Mr. Newbery. (3) S.AUST., S coast of Kangaroo Island, ± 10 mi. W of Vivonne Bay (NM & G. D. Seton): Larvae (9–16 Oct. 66) on fls. and tender young seed capsules of the spiny-intricate shrub, *Daviesia brevifolia* Lindl.—FABACEAE (det. MK). (Preserved = 5.)

• *Smyriodes serrata* (Walk.), 9 May 1857 (det. SF)—G.110 & 110A (possibly synonymous with *carburaria* Gn., 31 Dec. 1857). (1) S.AUST., Blackwood (NM): Larvae (Aug.–Oct.) on young lvs. of *Acacia pycnantha* (det. NM). Adults (A) fly late May–early Nov. (peak mid June–early Sept.) almost entirely ♂♂ coming to uv. light in the first few weeks of the season, with ♀♀ mostly later. However, the ♂♂ continue right through, with both sexes occurring in approximately equal numbers (at uv. light) during Sept.; univoltine. (Preserved = 1–6, 9; photos = 1, 2, 4, 4c, 5, 5c, 6.) (2) S.AUST., ± 3 mi. S of Monarto South railway station (NM & D. Bakker): Larva (afternoon of 6 Oct. 69) found crawling among lvs. on *Acacia calamifolia* Sweet ex Lindl. (det. MK). (Preserved = 5.)

Stathmorrhopa—see also *Fisera* and *Mnesampela*.

• *Stathmorrhopa macroptila* (Turner) (det. IC)—G.99. S.AUST., Blackwood (NM): Larvae (June–Sept.) on young and mature lvs. of *Eucalyptus leucoxylon* and *E. odorata* (dets. NM). Adults (A+) fly April–June (peak late April–May); the majority come to uv. light after 2300 hrs; univoltine. In fresh specimens, the uniformly dark sooty-brown of the forewings, thorax, and head, plus the almost total lack of maculation (but for an obscure dark discal dot in most males) will serve to distinguish this sp. from *Fisera eribola*, the only other geometrid with which it might be confused in this locality. See p. 13 regarding the adult resting-position. The eggs are rain-hatched. (Preserved = 1–6, 9; photos = 1, 2, 5, 6.)

Note: Higher up in the Mt. Lofty Range (Aldgate district) occurs what is probably a distinct but very closely-related species, never seen during six seasons at Blackwood: This moth flies during late Feb.–April, coming to uv. light mostly after 2300 hrs; the general appearance is close to *S. macroptila*, but the major forewing veins are traced with a soft brick-red, and the brown forewing groundcolor of fresh specimens is not as dark or sooty as in *macroptila*.

• *Stibaroma melanotoxa* Guest (det. IC)—G.81. S.AUST., Blackwood (NM): Larvae (May–Sept.) on mature lvs. of *Eucalyptus odorata* (det. NM); in later instars they are strictly nocturnal feeders, resting by day outstretched ("catocaline style") on bark or on other rough, brown areas of the branches and trunk. Adults (A+) fly late Feb.–early July (peak mid March–early June); the majority come to uv. light after 2300 hrs; univoltine. There may possibly be 2 spp. involved here but I suspect this is only one highly variable species with respect to both color and

maculation. First instar larval dispersal is notable. See McFarland (1972b: 237) for egg photos. (Preserved = 1-6, 9; photos = 1, 2, 5, 6.)

• *Stibaroma trigramma* Lower (det. IC)—G.104 (synonymous with *Cleora dolichoptila* Turner (det. NM); type ♂ in Qld. Museum, Brisbane). S.AUST., Blackwood (NM): Larvae (July-Sept.) on mature lvs. of *Eucalyptus odorata* (det. NM). Adults (A) fly mid March-early July (peak mid April-May) with the majority coming to uv. light after 2300 hrs; univoltine. They are quite variable in forewing maculation (and to a lesser extent in coloration), but do not approach the great variability seen in *S. melanotoxa*. The eggs are rain-hatched, and first instar larval dispersal is notable. (Preserved = 1-7, 9; photos = 1, 2, 5, 5c, 6.)

• *Symmetroctena peutheta* Turner (det. NM)—G.134. S.AUST., SW Yorke Pen., S end of Formy Bay, ± 5 mi. SW of Carribee Homestead, on beach sandhills (NM, N. B. Tindale, & P. Aitken): Larvae (2 Nov. 65) common on the small shrubby root-parasite, *Exocarpos sylvicolus* (FvM. ex Miq.) Stauffer (det. MK); feeding mostly on young growing tips of stems. Adults emerged late Nov. 65. (Preserved = 1, 4, 5, 6, 8dh, 9; photos = 1.)

• *Symmetroctena exprimataria* Walk. (det. SF)—G.135 & 135A. S.AUST., upper Yorke Peninsula, nr. Cunliffe (NM & N. B. Tindale); also, 4 mi. E of Two Wells, at Lewiston Park (NM, TN, & G. Furness): Larvae (most months) abundant on the large shrubby root-parasite, *Exocarpos aphyllus* R. Br. (det. MK), feeding primarily on floral parts and young tips. Adults fly most months. (Preserved = 1, 4, 5, 6, 8hh, 9; photos = 1, 5.)

• *Symmetroctena exprimataria* Walk. (det. IC)—G.233. W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Captive larvae (Jan. 73) readily accepted floral parts and new growth of *Exocarpos sparteus* R. Br. (det. WAH). Adults (B-) are multiple-brooded here. (Preserved = 1-6, 9.)

• *Symmetroctena leucoprosopa* Turner (det. IC, NM)—S.AUST., ± 4 mi. E of Two Wells, Lewiston Park (NM & TN): Larvae (19 March 67) on the tree, *Melaleuca lanceolata* Otto—MYRTACEAE (det. NM). Adults emerged April 67. (Preserved = 1, 6.)

Symmiges—see *Smyriodes*.

• *Syneora leucanthes* Turner (det. IC)—G.186. S.AUST., ± 1 mi. N of Grange, on the coast W of Adelaide, along Military Rd. (NM): Larvae (8 Aug. 67) abundant on the large shrub, *Melaleuca halmaturorum* FvM. ex Miq.—MYRTACEAE (det. MK). Adults emerged Sept.-Oct. 67. (Preserved = 1, 4-6, 9; photos = 1, 5.)

• *Syneora* sp., close to *lygdina* Turner (det. NM)—S.AUST., N. Flinders Range, nr. Arkaroola Homestead, in a dry-rocky gully (NM): Larvae (Oct. 69) on the large shrub, *Melaleuca glomerata* FvM. (det. MK). Adult ♀ emerged Nov. 69. (Preserved = 1, 6.)

• *Syneora* sp., close to *mundifera* Walk. (det. NM)—S.AUST., S coast of Kangaroo Is., ± 10 mi. W of Vivonne Bay, around borders of a small, freshwater lagoon (NM & G. D. Seton): Larvae (mid Oct. 66) on the dense shrub, *Melaleuca oraria* J. M. Black (det. MK). Adults (♂, ♀) emerged 5, 8 Nov. 66. (Preserved = 1, 6.)

• *Thalaina angulosa* Walk. (det. SF, IC)—G.100 & 100A. (1) S.AUST., Blackwood-Belair district (NM): Larvae (July-Sept.) regularly on young lvs. of *Acacia pycnantha*; captive larvae readily accepted the eastern Cootamundra wattle, **A. baileyana* FvM. (dets. NM). Adults (A) fly mid March-mid June (peak April-early May) with very few ♀♀ appearing prior to early May; univoltine. This is the only member of the genus I have taken at Blackwood. The eggs are rain-hatched. See McFarland (1972b: 241) for egg photos. (Preserved = 1-7, 9; photos = 1, 1c, 2, 5, 5c, 6.) (2) S.AUST., ± 3 mi. NE of Woodchester, nr. Hartley (NM): Larvae (6 July 68) common on *Acacia brachybotrya* Benth. (det. MK), and on *Cassia* sp. CAESALPINIACEAE (det. NM). (Preserved = 5; photos = 5, 5c.) (3) S.AUST., ± 5 mi. E of Two Wells, along roadside (NM & TN): Larvae (27 Aug. 66) common on *Cassia nemophila* Cunn. ex Vogel (det. NM).

• *Thalaina clara* Walk. (det. NM)—G.128. S.AUST., Naracoorte (eggs through TN): Captive larvae (May–June 70) readily accepted mature lvs. (only) of *Acacia mearnsii* DeWilld. (syn. = *A. mollissima* Black) (det. NM). Based on the larval maculation, it is apparent that *T. clara* larvae (unlike *T. angulosa* or *T. selenoea*) are adapted for living on acacias having finely-bipinnate (“feathery”) lvs., although they might conceivably accept certain of the other *Acacia* spp. as “forced” substitutes in captivity. Adults fly \pm April–May at Naracoorte (TN records); univoltine. The eggs are rain-hatched. See Common (1966b: 83) and Tillyard (1926: Pl. 33) for ♀ adult photos. (Preserved = 2–7, 9; photos = 2, 5, 6.)

• *Thalaina selenoea* Dbldy. (det. NM)—G.119 (almost certainly synonymous with *punctilinea* Walk.). S.AUST., Naracoorte (eggs through TN): Captive larvae (June–July 69) readily accepted mature lvs. (phyllodes) of the shrubby **Acacia iteaphylla* FvM. ex Benth. (det. MK); also casually accepted young lvs. of *A. pycnantha* and *A. mearnsii*, but much preferred the first species. Adults fly \pm April–May at Naracoorte (TN records); univoltine. The eggs are rain-hatched. See Common (1970: 844) for ♂ adult photo. (Preserved = 1, 2, 5–7, 9; photos = 2, 5, 6.)

• *Thalainodes macfarlandi* Wilson (det. J. O. Wilson)—G.180. N.TERR., 12 mi. E of Alice Springs (NM & TN): Captive larvae (June–Sept. 67) readily accepted mature (tough) phyllodes of *Acacia pycnantha* (det. NM) as a substitute foodplant at Blackwood, S.AUST. Adults (B \pm) fly April–June, probably widespread through many inland, semi-desert localities between Coober Pedy and Alice Springs; almost certainly univoltine. The eggs seem to be on the borderline of a rain-hatching tendency. For the original description and photos of this moth, see Wilson (1972). (Preserved = 1–6, 9; photos = 1, 1c, 2, 5.)

• *Zermizinga indocillisaria* Walk. (det. IC, SF)—G.185. S.AUST., Blackwood, and many other districts around Adelaide (NM): Larvae (winter–spring) are widespread through many natural habitat types here, feeding on a wide range of unrelated plants, mostly shrubs or dwarf shrubs; they are never (or rarely) common in any given locality, but are regularly encountered almost everywhere during bush-beating. They look rather like small larvae of *Ectropis excursaria* at first glance. A few specific foodplant records: *Bertya mitchellii* (Sond.) Muell. Arg. (S.AUST., \pm 3 mi. S of Monarto South, 6 Oct. 69), and *Beyeria leschenaultii* var. *latifolia* Grüning (S.AUST., Hallett Cove, Aug. 67)—both EUPHORBIACEAE (dets. MK); *Cassia nemophila* Cunn. ex Vogel—CAESALPINIACEAE (det. NM) (\pm 5 mi. W of Two Wells, S.AUST., 27 Aug. 66); *Exocarpos cupressiformis* and *Pultenaea largiflorens* var. *latifolia* (dets. NM) (Blackwood-Belair district, S.AUST., Aug.–Sept.). Adult ♂♂ (B+, at Blackwood) fly \pm May–Sept. (peak June), coming to uv. light mostly after 2300 hrs; the ♀♀ are brachypterous, most peculiar, and unable to fly. See Common (1966b: 83) for excellent ♂ & ♀ adult photos. I would expect first instar larval dispersal in this species. (Preserved = ♂ ♀ 1, 6; photos = ♀ 1, alive.)

Miscellaneous Unidentified Ennominae

• *Genus ? sp. ?* (probably undescribed) (det. SF, NM)—G.242. (This sp. may be fairly close to *Chlenias*, but it appears to warrant generic separation.) W.AUST., Geraldton district, in Spalding Park at Bluff Point, S side of Chapman R. (D. & NM): Larvae extremely abundant (July–Aug. 73) on new lvs. of *Grevillea pinaster* Meisn. (det. WAH). The situation here was very reminiscent of the periodic extreme abundance of my G.103 (*Chlenias*) larvae in Blackwood, S. AUST., where *Olearia ramulosa* was nearly stripped of foliage some years in certain localized areas. The way the colorful G.242 larvae blend with the intricate tangle of linear lvs. on their foodplant is also parallel to the situation in G.103. However, the prominent pair of shiny, black, subdorsal chazae on abdominal segment 2 (A-2), repeated again on A-8, separate these otherwise very “*Chlenias*-like” larvae from all *Chlenias* spp.

listed earlier; some individuals also have a similar (but smaller) pair of chazae on A-3, but in others they are totally missing on that segment. The highly variable adults fly \pm May–July; univoltine. (Preserved = 1, 4–6, 9; photos = 1, 5, 5c, 6.)

(B) SUBFAMILY GEOMETRINAE (SYNONYM = HEMITHEINAE)

Aelochroma—see *Terpna*.

● *Agathia* sp.? (det. NM)—Gm.421. N.QLD., \pm 14 mi. N of Cairns, Clifton Beach (D. & NM): Larva (8 May 72) on semi-mature lvs. (on fast-growing stems) of the sprawling shrub-vine, *Alyxia spicata* R. Br.—APOCYNACEAE (det. BH). The single half-grown larva was killed by a parasite. This tentative larval determination is based on illustrations and foodplant data from Singh (1953). See Tillyard (1926: Pl. 27) for *A. laetata* adult in color. (Preserved = 3rd instar larval head capsule and 8h.)

● *Austroterpna idiographa* Goldfinch (det. NM)—Gm.412. S.AUST., Highbury East, at 1136 Lower Northeast Rd. (E of Adelaide) (eggs through K. J. Sandery): Captive larvae (April–May 70) readily accepted young lvs. of *Acacia pycnantha* (det. NM). Adults (B–) fly March–early May & Sept.–Oct. (records from Sandery Coll., Highbury); extremely rare at Blackwood, where only one worn ♀ (early May 65) was taken in 6 consecutive years. (Preserved = 1–6, 9; photos = 1, 2, 5, 6.)

● *Austroterpna ?paratorna* (Meyr.) (det. IC)—Gm.405. S.AUST., N. Flinders Ranges, 21–23 mi. E of Copley (NM, P. & A. Taverna): Larvae (25 Oct. 69) on young lvs. of *Acacia rivalis* J. M. Black—MIMOSACEAE (det. S. A. Herbarium). Adults emerged mid Nov.–Dec. 69. I suspect that my Gm.412 and Gm.405 are one and the same species, but they have been recorded separately in my larval collection and notes. Gm.405 is somewhat less strongly-marked than 412, with a pale gray-frosted effect over the ♂ forewing. Both Gm.412 and 405 show a considerable size difference between the sexes, the males usually being notably smaller. (Preserved = 1, 2, 4–7, 9; photos = 1, 1c, 5, 5c, 6.)

● *Chlorocoma ?assimilis* (Lucas) (det. IC)—Gm.76. S.AUST., Blackwood-Belair district (NM): Larvae (July–Sept.; also autumn) frequent on young lvs. and growing tips of *Acacia pycnantha* (det. NM); also on new growth and fls. of *Acacia myrtifolia* (records of J. O. Wilson, Aug. 67, Aldinga, S.Aust.; NM & K. J. Sandery, 4 Sept. 71, Aldgate, S.Aust.). Adults (A) fly Sept.–June (peaks Nov. & Jan.–April) at Blackwood. See Common (1970: 849, fig. C) for final instar larva of this or a closely-related sp. (Preserved = 1–6, 8h, 9; photos = 1, 1c, 2, 5, 5c, 6.)

● *Chlorocoma cadmaria* (Gn.) (det. IC, SF)—Gm.130 & 130A. (1) S.AUST., 3½ mi. SE of Blackwood P.O. (NM): Larvae (Sept.–Oct. 65) on the slender woody shrub, *Leptospermum myrsinoides* (det. NM). Adults (C) fly Nov.–March at Blackwood; rare here, but probably more common near the scattered and localized patches of their foodplant. (Preserved = 1, 5, 6, 9; photos = 1.) (2) S.AUST., S coast of Kangaroo Island, \pm 10 mi. W of Vivonne Bay, around edge of a small, freshwater lagoon (NM & G. D. Seton): Larvae (1 Jan. 66) on *Darwinia micropetala* (FvM.) Benth.; also (mid Oct. 66) on *Melaleuca oraria* J. M. Black and young lvs. of *M. gibbosa* Labill.—all MYRTACEAE (dets. MK). See Tillyard (1926: Pl. 27) for adult in color. (Preserved = 1, 4–6, 9; photos = 1.)

● *Chlorocoma* sp., close to *cadmaria* (Gn.) (det. NM)—Gm.411. VIC., Red Hill (S of Melbourne) (eggs through D. R. Holmes): Captive larvae (Feb.–April 70) accepted mature lvs. of *Leptospermum myrsinoides* (det. NM), at Blackwood, S. Aust. (Preserved = 1–6, 9; photos = 5, 5c.)

● *Chlorocoma carenaria* Gn. (det. IC)—Gm.407. VIC., Red Hill (S of Melbourne) (eggs through D. R. Holmes): Captive larvae (April–May) readily accepted young

lvs. of *Acacia pycnantha* (det. NM), at Blackwood, S.Aust. Adults emerged mid-late June. (Preserved = 1-6; photos = 1, 5, 6.)

● *Chlorocoma dichloraria* Gn. (det. SF)—Gm.401. S.AUST., Naracoorte, at 13 Lochiel Ave. (NM & TN): Captive larvae (Jan. 69) readily accepted young lvs. of *Acacia pycnantha* (det. NM), at Blackwood. (Preserved = 1-3, 9; photos = 2.)

● *Chlorocoma externa* Walk. (det. SF)—Gm.155 (in part; see also the following *Chlorocoma* sp.). S.AUST., Blackwood-Belair district (NM): These larvae (most months, especially winter-spring) are the commoner of 2 closely-related *Chlorocomas* feeding on *Exocarpos cupressiformis* (det. NM). Adults (B+) fly Sept.-May (peaks Nov. & April), coming to uv. light esp. after 2300 hrs. This sp. is distinguished by the presence of small, dark discal dots on all wings, and by the lack of any middorsal, thoracic-abdominal stripe; the darker spots in the fringe (all wings) are a variable feature. (Preserved = 1, 4-6, 8h, 9; photos = 1, 2, 5, 6.)

● *Chlorocoma* sp., close to *externa* Walk. (det. SF)—Gm.155 (in part; see also the preceding *Chlorocoma*). S.AUST., Blackwood-Belair district (NM): Larvae (most months) on *Exocarpos cupressiformis* (det. NM). Adults (B-) fly Sept.-May, coming to uv. light esp. after 2300 hrs. This moth is distinguished from the preceding by the lack of any dark discal dots, by the presence of a light reddish, middorsal, thoracic-abdominal stripe, and by a more prominent pale cream border on the outer margins of both forewings and hindwings, just inside the fringe; darker spots in the fringe (all wings) are a variable feature. The two spp. are essentially identical in size (which varies). The genitalia of this moth and the preceding were found to be distinct (SF and K. Brookes, Nov. 70). It could be of great interest for a future lepidopterist to rear several long series of adults from eggs obtained in captivity from known females of both this form (middorsal stripe) and the preceding (discal dots; no stripe); I had hoped to do this when living at Blackwood, but never got around to it. (It is possible that, among my field-collected preserved larvae coded under Gm.155, both forms may be present, so I would caution anyone who might borrow this material to have this possibility in mind. It is, however, probable that most or all of the preserved alcoholic material is referable to the preceding sp., if these two forms are distinct.) (Preserved = ?, 9; photos = 1, 1c.)

● *Chlorocoma m. melocrossa* Meyr. (det. SF)—Gm.113. (1) S.AUST., Blackwood-Belair district (NM): Larvae (Sept.-Oct.) fairly common on the dwarf shrub, *Pultenaea largiflorens* var. *latifolia* (det. NM). Adults (B-) fly Oct.-Nov. & mid March-mid April (peak Oct.). The vivid green adult cannot be mistaken for any other "emerald" occurring here, if careful note is taken of the head and fringe coloration. (Preserved = 1, 4-7, 8h, 9; photos = 1, 5, 5c, 6, 6c.) (2) S.AUST., Mt. Lofty Range, nr. Upper Sturt (TN): Larvae (24 Sept. 67) not uncommon on the dwarf shrub, *Dillwynia hispida* (det. TN).

● "*Chlorocoma*" sp. (det. SF, NM)—Gm.168. (This sp. may warrant generic separation from *Chlorocoma*.) S.AUST., \pm 5 mi. E of Two Wells, along roadside (NM & TN): Larvae (Dec.-March) common on *Acacia ligulata* A. Cunn. ex Benth.; a few also on a single *A. salicina* Lindl. (dets. MK). Adults emerged April-May 67. The ♂ is the smallest immaculate, soft green geometrid occurring near Adelaide and could be mistaken for no other; the larval head capsules are also quite distinctive in this sp. (Preserved = 1, 5, 6, 9; photos = 1.)

● *Chlorocoma ?vertumnaria* Gn. (det. NM)—Gm.191. S.AUST., \pm 4 mi. S of Monarto South (NM & TN): Larvae (Sept.-Oct. 67) on *Acacia* sp. with long, \pm strap-like and rather thick phyllodes; stems purplish-tinged. Captive larvae (from eggs of a confined ♀) readily accepted young lvs. of *A. pycnantha* at Blackwood. Adults fly Oct.-Nov. and possibly other months as well. (Preserved = 1-6, 9; photos = 1, 2, 5, 6.)

● "*Crypsiphona*" *eremnopis* Turner (det. NM, IC)—Gm.190. (A synonym is *Lophothorax alamphodes* Turner, with type ♀ in A.N.I.C.; the type ♂ of *C. eremnopis* is also in A.N.I.C. Clearly this moth does not belong in *Crypsiphona*.) S. AUST., \pm 10

mi. W of Murray Bridge, at 2½–3 mi. S of Monarto South railway crossing (NM & TN): Larvae (8 Oct. 67) fairly common on the low-spreading and dense dwarf shrub, *Dodonaea bursariifolia* FvM.—SAPINDACEAE. This unique habitat, formerly rich in a great variety of native plant spp. (which are not well represented anywhere else near Adelaide), is now (1973) totally obliterated; it was on private farmland. There possibly remains some similar scrub country still intact, a little farther south along the same road (where "Progress" has not yet blossomed), but I do not recall ever seeing *D. bursariifolia* in that area. Adults emerged Nov. 67. (Preserved = 1, 5–7, 8dh, 9; photos = 1, 5, 6.)

● *Crypsiphona oculitaria* (Donovan) (det. SF; correct spelling of specific name has only one "c")—Gm.84, 84A, & 84B. (1) S.AUST., Blackwood (NM): Larvae (most months; especially May–June) on either mature or young lvs. of *Eucalyptus odorata* (det. NM). Adults (A+) fly Aug.–June (peak Nov.–April, especially Feb.). See Common (1966b: 85) for ♀ adult photo; Tillyard (1926: Pl. 39) for ♂. (Preserved = 1–7, 9; photos = 1, 1c, 2, 5–7.) (2) S.AUST., Coorong district, 2 mi. SSE of Salt Creek (J. J. H. Szent-Ivany): Larva (14 Nov. 67) on a mallee eucalypt, *Eucalyptus diversifolia* Bonpl. (det. MK). (Preserved = 5.)

● *Cyneoterpa wilsoni* Felder (det. SF, IC)—Gm.162. S.AUST., Blackwood (NM): Captive larvae (Jan.–Feb.) readily accepted young lvs. (only) of *Eucalyptus odorata* (det. NM). Adults (B–) fly Aug.–April (peak Dec.–Feb.); the majority come to u.v. light after 2300 hrs; see McFarland (1972b: 233) for egg photos. ♀♀ rarely seen. (Preserved = 1–7, 9; photos = 1, 2, 5, 6.)

● *Eucyclodes buprestaria* Gn. (det. NM)—Gm.175, 175A, 175B, & 175C. (1) S. AUST., Mt. Lofty Range, Upper Sturt district (Ironbank Rd.) to Aldgate (Heather Rd.) (NM, D. Bakker, TN; K. J. Sandery; A. Smith): Larvae (Mar.–April 67; Aug.–Sept. 69 & 71) fairly common on young, growing (reddish) tips, fls., fl. buds, and frs. of the slender-wiry parasitic twiner, *Cassytha glabella* (det. NM), which was mostly parasitizing sedges (Cyperaceae) and grasses (Poaceae) here, with a few parasitizing *Exocarpos cupressiformis* and *Leptospermum myrsinoides*. The larvae were found in all 3 situations, but primarily near the ground, where the supporting hosts of their foodplant were low, clump-forming perennial sedges and/or native grasses. Adults (B–) fly spring–early autumn (peaks Nov. & March); extremely rare at Blackwood. See McFarland (1972b: 233) for egg photos. (Preserved = 1–7, 9; photos = 1, 1c, 2, 5, 5c, 6, 7.) (2) S.AUST., Belair Nat. Park, ¼ mi. E of Belair railway station (NM & D. Bakker): Larva (14 Sept. 69) on *Cassytha pubescens* which was parasitizing *Leptospermum myrsinoides* (dets. NM); larvae apparently rare here. (3) S. AUST., Aldinga scrub, ± 3 mi. S of Port Willunga (P. & K. Sandery): Larva (20 Feb. 72) on fl. buds of *Cassytha* sp. (det. Sandery); this was probably *C. glabella* R. Br. (Preserved = 8d) (4) W.AUST., ± 16 mi. N of Geraldton, nr. Oakajee (D. & NM): Half-grown larva (28 July 72) on *Cassytha* sp. (close to *glabella* R. Br.) which was parasitizing shrubby *Casuarina campestris* Diels. (dets. NM). This moth is fairly common (B) at Drummond Cove, W.Aust., with by far the majority coming to u.v. light after 2300 hrs; multiple-brooded here (spring–autumn, with peaks in Sept.–Oct. and mid April–early May).

● *Eucyclodes pieroides* Walk. (det. IC)—Gm.420. N.QLD., ± 14 mi. N of Cairns, at Clifton Beach (D. & NM): Half-grown larva (9 May 72) on fls. & fl. buds of the shrub, *Fenzlia obtusa* Endl.—MYRTACEAE (det. BH); also one fresh ♂ adult (same date) was discovered at rest on one of these bushes (collected). Sexual dimorphism is striking in this species. Adult ♀ emerged 29 June 72. See Common (1970: Pl. 8, fig. L) for excellent color painting of ♂ adult; Tillyard (1926: Pl. 33, 39) for poor photos of both sexes. (Preserved = ♂ ♀ 1, 6, 7, 9; photos = 5.)

● *Eucyclodes* sp. (det. NM)—Gm.413. N.S.W., Oxford Falls (D. Sands): Larvae (July–Aug. 70) on lvs. of *Dodonaea triquetra* Andr. (det. Sands). These larvae are distinct from either of the foregoing *Eucyclodes* spp., but show a closer kinship with

E. pieroides. Unfortunately no adults were successfully reared. (Preserved = presumed 5; photos = presumed 5.)

• *Euloxia fugitivaria* (Gn.) (det. NM)—Gm.403 & 403A (possibly synonymous with *isadelpha* Turner; type from Waroona, W.AUST.). S.AUST., Highbury East, nr. 1136 Lower Northeast Rd., and Athelstone (Addison Ave.), at base of Black Hill (D. & NM, P. & K. J. Sandery): Larvae (Oct.–March) on the flimsy but upright dwarf shrub, *Pimelea stricta* Meisn.—THYMELAEACEAE (det. MK). Adults (B–) fly late Aug.–Sept.; unlike most Geometrinae here, this sp. is strictly univoltine. (Preserved = 1–7, 8hh, 9; photos = 1, 1c, 2, 5, 5c, 6, 6c.)

• *Euloxia meracula* Turner (det. NM)—Gm.400. S.AUST., Port Lincoln, SE of town center (Torrens St.), along beach (TN; D. & NM): Larvae (Sept.–Oct. 68 & 71) common on the “soft” lvs. of the dense and compact low shrub, *Pimelea serpyllifolia* R. Br.—THYMELAEACEAE (det. MK). Adults fly ± May–June; strictly univoltine. (Preserved = 1–6, 8h, 9; photos = 1, 2, 5, 6.)

• *Gelasma centrophylla* (Meyr.) (det. NM)—Gm.406. VIC., Red Hill, S of Melbourne (eggs through D. R. Holmes): Captive larvae (Jan.–Feb. 70) reared at Blackwood, where they casually accepted *Leptospermum myrsinoides* (det. NM), but all died by 2nd–3rd instar; this could have been due to unsuitable foodplant, wrong rearing conditions, and/or disease, which of these was not clear. The record is included only because it could provide a useful clue; these larvae were growing well, up to a point! Adults fly summer–? (Preserved = 1–4.)

• *Gelasma rhodocosma* Meyr. (det. IC)—Gm.416. N.QLD., Atherton Tableland (± 2500' el.), 12 mi. NE of Atherton, nr. Tinaroo Pines Caravan Park (D. & NM): Eggs and larvae (April–June 72) on young and semi-mature lvs. of *Eucalyptus alba* Reinw. ex Blum and *E. ?polycarpa* FvM. (dets. BH). Adults emerged April–May 72. (Preserved = 1, 2, 5, 6, 8d, 9.)

• *Gelasma semicrocea* (Walk.) (det. IC, SF)—Gm.89 & 89A. (A synonym is *Chlorocoma ipomopsis* Lower, in S.A.M., det. NM). (1) S.AUST., Blackwood (NM): Larvae (most months) on young lvs. of *Eucalyptus odorata* (det. NM). Adults (A+) fly Sept.–July (peaks Nov.–Jan., March–April, & June); the majority of individuals come to uv. light after 2300 hrs. (Preserved = 1–6, 9; photos = 1, 1c, 2, 5, 6.) (2) VIC., Red Hill, S of Melbourne (eggs through D. R. Holmes): Captive larvae (Dec. 69) readily accepted young lvs. of *E. odorata* at Blackwood, S. Aust. (3). This sp. also appears to be widespread in the forested SW of W.AUST.

• *Heliomystis electrica* Meyr. (det. NM)—Gm.409, 409A, & 409B. (1) S.AUST., higher elevations of the Mt. Lofty Range, especially Upper Sturt district to Aldgate (P. Taverna, A. Smith, & NM): Adults (B–) fly late Oct.–March, with the majority coming to uv. light only after 2300 hrs and even up to dawn. Never seen at Blackwood in 6 years. (2) VIC., Red Hill, S of Melbourne (eggs through D. R. Holmes): Captive larvae (April–May 70; reared at Blackwood) readily accepted luxuriant and soft young lvs. (from recently-burned trunk resprouts) of (only) *Eucalyptus obliqua* (det. MK). Also offered were young, semi-mature, and old lvs. of *E. odorata*, *E. leucoxylon*, and *E. fasciculosa*; the first two were absolutely refused, but *fasciculosa* was at first casually accepted; then they became “sickly” on it and were only saved by switching them over to *obliqua*, which was the last eucalypt tried. Upon the latter they soon regained excellent health, feeding avidly, reaching full size, and eventually forming large and perfect pupae and adults. It seems probable that the distribution of *electrica*, at least in the Mt. Lofty Range, may closely follow that of *E. obliqua*; this eucalypt does not grow at elevations as low as Blackwood, although it is well represented in the higher parts of Belair Nat. Park (several miles to the east), and thence on to Upper Sturt, Aldgate, and Mt. Lofty, etc. See Common (1966b: 85) for ♂ adult photo. (Preserved = 1–7, 9; photos = 1, 2, 5, 5c, 6.) (3) An interesting locality record: 2 ♂ adults came to uv. light in Oct. 71, nr. Hopetoun, W. AUST. (S of Ravensthorpe). Forewings (upperside) were a deep sooty-brown, with the maculation rather obscured.

• *Hypobapta barnardi* Goldfinch (det. IC, NM)—Gm.402. N.S.W., Como West,

suburb of Sydney (eggs through L. S. Willan & K. D. Fairey): Captive larvae (Nov. 69) readily accepted young and semi-mature lvs. of *Eucalyptus odorata* (det. NM), at Blackwood, S.Aust. Adults emerged Dec. 69. (Preserved = 1-7; photos = 1.)

● *Hypobapta eugramma* (Lower, 1892) (det. IC)—Gm. 125 & 125A. (It is quite possible that *diffundens* Lucas, 1891, will prove to be a synonym; if so, this name would have priority.) S.AUST., Blackwood (NM): Larvae (late spring-autumn) on young and semi-mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B+) fly late Oct.-early April (peak Jan.-Feb.), especially on hot nights. Sexual dimorphism is fairly noticeable, primarily in the size difference (♂ often much smaller). See Common (1966b: 85 and 1970: 849, fig. P) for ♂ adult photos; McFarland (1972b: 233, 245) for egg photos. (Preserved = 1-7, 8d, 9; photos = 1, 2, 5, 6.)

● *Hypobapta percomptaria* (Gn.) (det. IC)—Gm. 88 & 88A. S.AUST., Blackwood (NM): Larvae (spring-autumn) on young and mature lvs. of *Eucalyptus odorata* and *E. leucoxylon* (dets. NM). Adults (B-) fly late Sept.-early May (peak Jan.-April). An aberrant melanic ♂ of this sp. was taken at uv. light in Belair Nat. Park, 1 April 71, R. Fisher, collector. (Preserved = 1-7, 9; photos = 1, 1c, 2, 3, 5, 5c, 6.)

Lophothorax—see "*Crypsiphona*" *eremnopis*.

● *Metallochloa militaris* (Lucas) (det. IC)—Gm. 422. N.QLD., Freshwater (N of Cairns), at Limberlost Nursery (D. & NM with L. Abell): Distinctive larva (9 May 72) on fls. & fl. buds of the tree, "star-fruit" or "five-corner" (edible), *Averrhoa carambola* L.—OXALIDACEAE (det. at nursery). Adult ♀ emerged 1 June 72. (Preserved = 1, 6, 9.)

● *Pingasa chlora* (Stoll) (det. IC)—Gm. 417. N.QLD., Atherton Tableland (± 2500'), 12 mi. NE of Atherton, at Tinaroo Pines Caravan Park (D. & NM): Captive larvae (May-June 72) accepted young and semi-mature lvs. of the rainforest tree, *Euroschinus falcata* Hook. f.—ANACARDIACEAE (det. A. Irvine). Adults emerged early July 72. (Preserved = 1-7, 9; photos = 5.)

● "*Pingasa*" *emiliaria* (Gn.) (det. IC)—Gm. 419. (The quotation marks around *Pingasa* are mine; *emiliaria* does not appear to belong in this genus.) N.QLD., Atherton Tableland (± 2500' el.), nr. Tinaroo Pines Caravan Park (D. & NM): Eggs and larvae (May-June 72) on young and mature lvs. of *Eucalyptus* ?*polycarpa* FvM. and *E. ?drepanophylla*—MYRTACEAE (dets. BH); by far the majority were on small saplings of the former eucalypt, in a grassy-roadside situation (the saplings were re-sprouts, in response to cutting back about a year before). The mature larvae have a surprisingly close (superficial) resemblance to the larvae of *Crypsiphona oculitaria*. Adults emerged June-early July 72. (Preserved = 1-7, 8h, 9; photos = 5.)

Prasinocyma—see also *Gelasma*.

● *Prasinocyma ocyptera* Meyr. (det. SF)—Gm. 169, 169A, 169B, & 169C. (1) S. AUST., ± 5 mi. E of Two Wells (NM & TN): Larvae (19 March 67) mostly on a single tree of *Acacia salicina* Lindl., and a few on *A. ligulata* A. Cunn. ex Benth. (dets. MK). An adult ♀ emerged late March 67. (Preserved = 1, 5, 6; photos = 1.) (2) S.AUST., ± 47 mi. N of Hawker, at Commodore Swamp (NM, A. & P. Taverna): Adults freshly-emerged (24 Oct. 69), coming to uv. light in a dense thicket of *Acacia victoriae* Benth. (det. MK); larvae obtained from a confined ♀ taken here readily accepted the soft new growth (lvs., frs., and buds) of this acacia. (Preserved = 1-3, 5; photos = 1, 6.) (3) S.AUST., Flinders Ranges, at foot of Aroona Dam, SSW of Copley (NM): Larvae (3 Nov. 69) on young lvs. of *A. salicina* (det. NM). (Preserved = 1, 5; photos = 1, 5) (4) S.AUST., Leigh Creek (NM & G. Gregory): Adults (2 Nov. 69) at light; confined for eggs. Resulting larvae reared at Blackwood, S.Aust., where they readily accepted young lvs. of *Acacia pycnantha* (det. NM). (Preserved = 1, 5, 6; photos = 2.)

● *Sterictopsis argyraspis* (Lower) (det. IC)—Gm. 79. S.AUST., Blackwood (NM): Larvae (most months) on young and mature lvs. of *Eucalyptus odorata* (det. NM).

Adults (A) fly Oct.–early May (peaks Nov.–Dec. & March). (Preserved = 1–7, 9; photos = 1, 2, 4, 4c, 5, 6.)

• *Terpna* sp. nov. (det. SF, IC)—Gm.156, 156A, & 156B. (Adult appearance is quite close to *mnitaria* Goldfinch, but it is clearly not that species; for illus. of *mnitaria*, see Common, 1966b: 85.) S.AUST., coastal bluffs at Hallett Cove, S of Adelaide (D. & NM, TN, K. Sandery); also nr. American River and Kingscote, Kangaroo Island (NM): Larvae (peaks June–Sept. & Jan.–March) on the low and dense shrub, *Beyeria leschenaultii* var. *latifolia* Grüning—EUPHORBIACEAE (det. MK); they match the mature lvs. of their foodplant to perfection, in respect to both dorsal and ventral color-maculation. Adults (B) fly late Sept.–March (peak Oct.–early Nov.). We have seen them in diurnal flight (1100–1200 hrs \pm) on several occasions (NM and Sandery); this was not in response to disturbance. They sometimes rest conspicuously on tops of bushes (usually the foodplant); they may also rest on the lichen-covered cliffs and rocks of the Hallett Cove habitat, where they would blend in exceedingly well. (The ♀♀ match the pale green lichen patches beautifully, but the ♂♂ are a much darker and richer shade of green. The greens of both sexes change and fade rapidly in the collection, even when specimens are kept in the dark.) (Preserved = 1–7, 8d, 9; photos = 1, 1c, 2, 5, 5c, 6, 7.)

• *Thalassodes pilaria* Gn. (det. SF)—Gm.418. N.QLD., Atherton Tableland (\pm 2500' el.), 12 mi. NE of Atherton, at Tinaroo Pines Caravan Park (D. & NM): Captive larvae (May–early June 72) readily accepted young and semi-mature lvs. of *Eucalyptus* ?*polycarpa* FvM. (det. BH). Many adults emerged mid–late June 72. (Preserved = 1–7, 9; photos = 5.)

Miscellaneous Unidentified Geometrinae

• *Genus?* sp.?—Gm.174. S.AUST., \pm 4 mi. E of Two Wells, Lewiston Park (D. & NM; TN); also 1 mi. S of Monarto South railway station (NM & TN): Larvae (May–Nov.) on native “pine,” *Callitris preissii* Miq.—CUPRESSACEAE (det. MK); often obtained by beating but never common. Adults have not been seen in the field, nor were any ever successfully reared, even after several attempts. This record is included here in order to draw attention to the existence of this small emerald, in hopes that some future worker will eventually succeed in rearing it, and thus learn its identity. (Should this ever occur, I would be most interested to hear about it!) This larva should not be mistaken for that of my G.170 (see *Corula*, under Ennominae). The green larvae of both these spp. are present on the same trees, in the same localities, at the same seasons of the year. However, those of Gm.174 show one of the typical geometrine larval body-profiles (and head shapes), and are also typically geometrine in all details of behavior. Their growth-rate is exceedingly slow; larval mortality is high in captivity if conditions are not suitable in every detail. (Preserved = 4–6, 8h, 9; photos = 4 or 5.)

• *Genus?* sp.? (det. IC, SF, NM)—Gm.404 (fairly close to *Chlorocoma* in superficial appearance, but probably belongs in another genus). S.AUST., N. Flinders Ranges, 21–23 mi. E of Copley (NM, P. & A. Taverna): Larvae (25 Oct. 69) on young and mature lvs. of *Acacia rivalis* J. M. Black (det. S. A. Herbarium); at Blackwood, S. Aust., where this rearing was completed, they readily switched over to young lvs. of *A. pycnantha* for a substitute foodplant. Many adults emerged Nov.–Dec. 69. The wing shapes (especially of the ♂) are unique among the South Australian emeralds; this alone will separate them from all other immaculate green geometrines here. (An adult series, representing this same sp., is in the A.N.I.C., collected by I. F. B. Common, at 28 mi. W of Madura, W.AUST., 30 April 1968.) (Preserved = 1, 5, 6, 9; photos = 1, 2, 5, 6.)

(C) SUBFAMILY LARENTIINAE (SYNONYM = HYDRIOMENINAE)

• *Chloroclystis destructata* Walk. (det. SF)—G.87 & 87A; G.123 (syn. = *catastrepes* Meyr.; det. SF). S.AUST., 3 mi. S of Monarto South, 4 mi. SE of Wistow, and in

the Blackwood-Belair district (NM): Larvae (autumn–winter–spring) on fls. and fl. buds of various unrelated plants, including goldenrod, **Solidago* sp.—ASTERACEAE (in a garden); the native *Clematis microphylla* DC.—RANUNCULACEAE; *Acacia* spp.; *Bertya mitchellii* (Sond.) Muell. Arg.—EUPHORBIACEAE (dets. MK, NM). Adults (B+) fly most months (Blackwood). (Preserved = 1, 4–6, 9; photos = only *Clematis* in habitat.)

• *Chloroclystis* sp., either *anaspila* Meyr. or *filata* Gn. (det. NM)—G.216. S.AUST., Blackwood (NM): Larvae (28 Sept. 69) on lvs. & buds of *Pultenaea largiflorens* var. *latifolia* (det. NM). Adult emerged 13 Nov. 69. (Preserved = 1, 5, 6.)

• *Cidaria uncinata* (Gn.) (det. IC)—G.96. S.AUST., Blackwood (NM): Larvae (autumn–winter–spring) on young lvs. and fl. buds of *Hibbertia stricta* (det. NM). Adults (B-) April & late Aug.–Oct. See Common (1966b: 83) for ♂ adult photo. (Preserved = 1–6, 9; photos = 1, 2, 5.)

• *Cidaria* ?sp. nov. (det. SF)—G.149. S.AUST., ± 8 mi. NE of Two Wells, on white sand hills (NM & TN): Larvae (20, 27 Aug. 66) on fl. buds & fls. of *Hibbertia virgata* R. Br. ex DC. (det. MK). Emerged 18, 23 Sept. 66. Genitalia studied indicate that this slightly larger *Cidaria* is distinct from *uncinata*; larval differences lend additional support to this conclusion. More specimens are needed. (Preserved = 1, 5, 6; photos = 1, 5c.)

• *Euchoeca rubropunctaria* Dbldy. (det. IC, SF)—G.121 (a synonym is *risata* Gn.). S.AUST., Blackwood (NM): Captive larvae (Sept.–Oct.) readily accepted *Haloragis heterophylla* (det. NM). I am certain *Haloragis* is the usual foodplant here. Adults (A) recorded for all months (peaks Sept. & Nov.); very scarce from May–July. (Preserved = 1–6, 9; photos = 2.)

• “*Euphyia*” *actinipha* (Lower) (det. IC)—G.98. (The quotation marks around *Euphyia* are mine.) S.AUST., Blackwood (NM): Captive larvae (June 65) readily accepted **Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars—FABACEAE (det. NM). Adults (D) fly April–May. (Preserved = 1–6, 9; photos = 1, 5.)

• “*Euphyia*” *squamulata* Warren (det. SF)—G.85. S.AUST., Blackwood (NM): Captive larvae (May–June) casually accepted fls. and young growth of *Olearia ramulosa* (det. NM). Adults (B+) fly mid Feb.–June; probably univoltine. (Preserved = 1–4, ?5, 9; photos = 2, 2c.)

• “*Euphyia*” sp.? (det. IC, SF, NM)—G.196. S.AUST., ± 4 mi. S of Ashbourne, nr. “Tooperang Scrub” (Mr. & Mrs. J. O. Wilson): One larva (6 Aug. 68) on young growing tips of *Casuarina paludosa* var. *robusta* Macklin. (det. MK). Adult (♂) emerged 20 Sept. 68. Only one adult (a fresh ♂) was ever taken in 6 years at Blackwood, on 26 Oct. 65, at u.v. light; probably univoltine. The latter specimen is deposited in the B.M.(N.H.). This moth could be mistaken for no other sp.; I could find nothing to compare with it in any of the major Australian collections visited. The prominent eyes, particularly in the pupa, are one of its notable features. (Preserved = ♂ 1, 4, 6, 7, 9; photos = ♂ 1, 5, 6.)

Hydrelia—see *Euchoeca*.

• *Microdes orichares* Turner (det. NM)—S.AUST., Blackwood (NM): Larva (12 Sept. 65) on lvs. of *Olearia ramulosa* (det. NM). Adult (♀) emerged 12 Oct. 65. (Preserved = 1.)

• *Microdes squamulata* (Gn.) (det. IC, SF)—G.102; ?G.117. S.AUST., Blackwood (NM): Larvae (winter–early spring) on young lvs., fls., and buds of several *Acacia* spp.; in a garden common every winter on tender young lvs. of *A. baileyana* FvM. (det. NM). Adults (A) fly Oct.–July (peaks Nov. & May–June). (Preserved = 1, 5, 6, 9; photos = 1, 5.)

• *Poecilasthena ischnophrica* Turner (det. NM)—G.173 (closely matches a specimen labelled “type” in Qld. Museum, Brisbane). S.AUST., Belair Nat. Park, 1 mi. E of Belair railway station (NM & D. Bakker): Larvae (mid Sept. 69) abundant, feeding on tough, mature lvs. of *Leptospermum myrsinoides* (det. NM). Adults never taken at Blackwood; probably restricted to limited areas where the foodplant grows,

as it is a weak flier. I had never before encountered these larvae on this plant, although I had been collecting in the same locality every winter-spring (and frequently beating *Leptospermum*) since 1965; probably univoltine and cyclic. (Preserved = 1, 5, 6.)

● *Poecilasthena pulchraria* Dbldy. (det. IC, SF)—G.144. S.AUST., Blackwood-Belair district (NM): Captive larvae (June-early Aug.) readily accepted mature lvs., fls., and green fruits of the semi-woody, mat-forming "native cranberry," *Astroloma humifusum* (det. MK). From a vast array of native plants and weeds offered (to two different batches of these larvae), only *A. humifusum* proved acceptable, and it was taken avidly; rapid and healthy growth resulted. This is very probably a correct interpretation of the "preferred" or "true" foodplant of this moth, in the locality named. Adults (C, at Blackwood) recorded for most months (peak Nov.-Dec.). (Preserved = 1-6, 9; photos = 1, 5, 6.)

● *Xanthorhoe sodaliata* Walk. (det. SF)—G.139. S.AUST., Glenelg (J. O. Wilson): Captive larvae (Sept. 71) readily accepted lvs., salmon-pink fls., and buds of scarlet pimpernel, a small annual weed, *Anagallis arvensis* L.—PRIMULACEAE (det. NM). I had previously attempted to rear this sp. at Blackwood without success, having offered the captive larvae various low-weedy, herbaceous plants, but *Anagallis* was not among them; other plants, such as clovers, *Plantago*, etc., were refused. The larvae reared by Wilson (on *Anagallis*) were clearly on a preferred foodplant and were thriving in last instar when I saw them. Adults (B+, at Blackwood) fly Sept.-Dec.; univoltine. (Preserved = 1.)

● *Xanthorhoe subidaria* Gn. (det. SF, IC)—G.138. S.AUST., Blackwood (NM): Captive larvae (July-Aug.) readily accepted a bur clover, *Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars (= *M. denticulata*)—FABACEAE (det. NM). Adults (A) recorded for all months (peak Sept.-Nov.). (Preserved = 1-6, 9; photos = 5c.)

● *Xanthorhoe vacuaria* Gn. (det. SF)—G.213 (a synonym = *solutata* Walk.). S. AUST., Blackwood (NM): Captive larvae (April-May 69) readily accepted *Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars—FABACEAE (det. NM). I have no records of adult abundance or flight season for this species. (Preserved = 1-5, 9; photos = 2.)

● *Xanthorhoe vicissata* (Gn.) (det. IC, SF)—G.92. S.AUST., Blackwood (NM): Captive larvae (May-June) accepted a wide range of unrelated herbaceous plants (and also one semi-woody dwarf-shrub), as follows: **Centaurium* sp.—GENTIANACEAE; **Chenopodium* sp.—CHENOPODIACEAE; *Hibbertia* sp.; *Lythrum hyssopifolia* L.—LYTHRACEAE; a weedy *Malva* sp.—MALVACEAE; **Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars—FABACEAE; **Mentha* sp.—LAMIACEAE; **Plantago lanceolata* L.—PLANTAGINACEAE; **Polygonum* sp.—POLYGONACEAE; fls. of goldenrod, **Solidago* sp.—ASTERACEAE; and chickweed, **Stellaria* sp.—CARYOPHYLLACEAE (dets. NM); after 1st instar, they were reared to maturity on a combination of *Medicago* and *Plantago* lvs. (both common lawn weeds here) which they ate avidly. Adults (A) fly March-April (peak late March); univoltine. The eggs seem to be on the borderline of a rain-hatching tendency. (Preserved = 1-6, 9; photos = 1, 1c, 2, 5).

(D) SUBFAMILY OENOCHROMINAE (OENOCHROMATINAE)

● *Arhodia lasiocamparia* Gn. (det. IC, SF)—G.124. S.AUST., Blackwood (NM): Captive larvae (Nov.-Dec.) readily accepted young lvs. of *Eucalyptus odorata* (det. NM); I also have 3 field-records of larvae collected on 3 different (unidentified) *Eucalyptus* spp., in the Blackwood-Belair district and at Black Hill, E of Adelaide (NM & TN). Adults (B+) fly Sept.-mid March (peak late Oct.-Dec.); the majority come to u.v. light only after 2300 hrs (♀ ♀ rarely seen); univoltine. Color forms vary considerably; a pale pinkish-tinged form (rarely seen at Blackwood) was often taken at Upper Sturt. First instar larval dispersal is notable in this species. See McFarland (1972b: 233) for egg photos. (Preserved = 1-6, 9; photos = 1, 1c, 2, 5, 5c, 6.)

• *Arhodia ?retractaria* Walker (det. SF)—G.163 (clearly distinct from *lasiocamparia*). S.AUST., ± 5 mi. W of Springton (NE of Adelaide) (TN): A single, long, encircling-band type of egg mass was found attached to a thin stem of a *Casuarina* sp. at roadside (late Dec. 66). Resulting larvae (Jan.) reared at Blackwood; they absolutely refused *Casuarina* spp. offered, but readily accepted young lvs. of *Eucalyptus odorata* (det. NM). Adults (3 ♂♂, 1 ♀) emerged late Nov.—early Dec. 68, after 22 months in the pupal stage. (I did not attempt to break the diapause between Sept.—Dec. 67, as I was away at the time; the pupae thus passed through a second summer and winter in diapause. Moisture applied from Sept.—Nov. 68 brought out the adults.) First instar larval dispersal was observed in this species. Probably univoltine. (Preserved = 1–6, 9; photos = 1, 5, 6.)

Cycloprorodes—see “*Chlenias*” *melanoxyta* Meyr. (Ennominae).

Descoreba—see *Arhodia*.

• *Dichromodes anelictis* Meyr. (det. NM)—W.VIC., Lowan Reserve, ± 5 mi. S of Kiata (NM): Larvae (28 Sept. 67) on *Baeckea behrii* (Schldl.) FvM.—MYRTACEAE (det. MK). (Preserved = ♂ 1, 6.)

• *Dichromodes atosignata* Walk. (det. NM)—G.187. W.VIC., Lowan Reserve, ± 5 mi. S of Kiata (NM): Larvae (28 Sept. 67) very abundant on *Baeckea behrii* (det. MK). Adults emerged Oct.—Nov.; highly variable in coloring and maculation. (Preserved = 1, 4–6.)

• *Dichromodes* sp., close to *eusurpatrix* Prout & *exsignata* Walk. (det. SF, NM)—G.164. (1) S.AUST., $3\frac{1}{2}$ mi. SE of Blackwood P.O. and Belair Nat. Park, 1 mi. E of Belair railway station (NM & TN): Larvae (Oct.—Dec. 66) abundant in the first locality, on tough, mature lvs. of *Leptospermum myrsinoides* (det. NM); scarce in the second locality although the foodplant was common there. Adults emerged early Oct. 67, after 9 months in pupal diapause; univoltine. (Preserved = 1, 4–7, 9; photos = 1, 4–6.) (2) S.AUST., ± 1 mi. N of Coonalpyn (NM): Larvae (28 Dec. 68) on *Leptospermum coriaceum* (FvM. ex Miq.) Cheel; also present on *Leptospermum* sp. at ± 4 mi. E of Lucindale, S.AUST., 26 Dec. 68 (NM & TN).

• *Dichromodes explanata* Walk. (det. NM)—G.150 & 150A. (1) S.AUST., ± 8 mi. NE of Two Wells, on white sandhills (NM & TN): Larvae (20, 27 Aug. 66) on young lvs. of the erect shrub, *Calytrix involucreta* J. M. Black (det. MK). Adults emerged mid Oct. 66; little variation was evident in the specimens seen. (Preserved = 1, 4–6, 9; photos = 1, 5, 5c.) (2) S.AUST., Athelstone, at foot of Black Hill (end of Addison Ave.) (NM): Larvae (15 June 68), mostly half-grown, abundant on *Calytrix tetragona* (det. NM). (3) S.AUST., S coast of Kangaroo Island, ± 10 mi. W of Vivonne Bay (NM & G. D. Seton): Larva (12 Oct. 66) on the dwarf shrub, *Lhotskya* sp. (= *Calytrix*)—MYRTACEAE (det. MK). (Preserved = 5.)

• *Dichromodes limosa* Turner (det. IC)—G.227. N.QLD., Clifton Beach, ± 14 mi. N of Cairns (D. & NM): Larvae (9 May 72) abundant on fls., buds, & young lvs. of the shrub, *Fenzlia obtusa* Endl.—MYRTACEAE (det. BH). Adults emerged early–mid June 72. (Preserved = 1, 5, 6, 8h, 9.)

• *Dichromodes partitaria* Walk. (det. NM)—G.158. S.AUST., S coast of Kangaroo Is., ± 10 mi. W of Vivonne Bay (NM & G. D. Seton): Larvae (mid Oct. 66) primarily on lvs. of *Melaleuca oraria* J. M. Black; a few also beaten from *M. gibbosa* Labill.—MYRTACEAE (dets. MK), but the former appears to be preferred here. (Preserved = 1, 4–6, 9.)

A comment on adults of the genus Dichromodes: These geometrids appear to occupy much the same ecological niches in Australia as do adults of *Semiothisa* spp. (Ennominae) in North America. They are highly variable as to coloration, but grays, tans, browns, and red-browns predominate, with nearly all spp. being cryptically colored and marked to match the soil, rock surfaces, leaf litter, or small dead leaves, etc. Although essentially nocturnal in activity, they are easily alarmed to flight in the daytime; the characteristic behavior is to fly up before the walker, only

to land again on the ground a short distance away, with wings pressed flat against the ground and the hindwings totally covering the forewings (planniform position).

Dinophalus—see also *Lissomma* and "Miscellaneous Unidentified Oenochrominae" (end of this section).

• *Dinophalus drakei* (Prout) (det. IC, SF)—G.194. S.AUST., Athelstone, nr. foot of Black Hill (end of Addison Ave., E of Adelaide) (TN): The original ♀ adult (15 Oct. 67) came to uv. light; it was given to me and eggs were obtained. Captive larvae (Nov. 67) readily accepted only the tender young linear lvs. of the dense, tough-sclerophyll shrub, *Hakea rostrata* (det. NM). Adults emerged late Oct. 68; univoltine. See McFarland (1972b: 235) for egg photo. (Preserved = 1–6, 9; photos = 1, 2, 6.)

• *Dinophalus serpentaria* (Gn.) (det. IC, NM)—G.193 & 193A (a synonym = *undulifera* Walk.). (1) S.AUST., 3.3 mi. S of Monarto South railway station (NM & TN): The original ♀ adult (8 Oct. 67) came to uv. light and was confined for eggs. The resulting larvae were reared at Blackwood, where they readily accepted tender young lvs. (only) of *Hakea rostrata* (det. NM); univoltine. (Preserved = 1, 2, 5, 9; photos = 1, 2, 5.) (2) W.AUST., nr. Red Bluff, ± 3 mi. S of Kalbarri (D. & NM): One larva, identical to the above (late Nov.–early Dec. 71), on tender young lvs. of *Grevillea ?trachytheca* FvM. (det. NM). A deformed adult ♂ emerged 13 Jan. 72. (Preserved = 1, 6; photos = 5.)

• *Hypographa aristarcha* Prout (det. IC, SF)—G.184. (1) S.AUST., S coast of Kangaroo Island, ± 10 mi. W of Vivonne Bay (NM & E. C. Jaeger): The original ♀ adult (6 Sept. 67) came to uv. light and was confined for eggs. The resulting larvae were reared at Blackwood, where they readily accepted fls. and young lvs. (only) of *Hakea rostrata* (det. NM); they also accepted tender young lvs. of the highly-sclerophyll and spiny low shrub, *Isopogon ceratophyllus*, but the rearing was completed using only *Hakea*, upon which they thrived. Adults of this most peculiar, large geometrid (with a veliform resting position) fly from late winter–spring; univoltine. See McFarland (1972b: 235) for egg photos. (Preserved = 1–6, 9; photos = 1, 2, 4–6.) (2) I know of two recent mainland S. AUST. records as follows: (a) Athelstone, at 39 Addison Ave., nr. foot of Black Hill, 13 Oct. 67, a fresh adult ♀ at uv. light (J. J. H. Szent-Ivany); (b) nr. Kingston, 29 Aug. 72, a fresh ♀ at uv. light (TN). (3) I collected 13 mostly fresh adults (12 ♂♂, 1 ♀) of what appears to be a very closely-related sp. (if it is not, in fact, a ssp. of *aristarcha*), in W.AUST., in the Stirling Ranges, nr. Toolbrunup Peak, 19 Nov. 68, at uv. light. (Preserved = 1; photos = 1.) See p. 13 regarding the adult resting-position.

• "*Hypographa*" *epiodes* Turner (det. NM)—G.205. (1) W.AUST., Stirling Ranges, nr. Toolbrunup Peak, in a roadside gravel-quarry (NM & N. B. Tindale): Larvae (19 Nov. 68) feeding at night on young lvs. of *Banksia sphaerocarpa* R. Br. (det. WAH). An adult ♂ emerged 13 Oct. 69, after over 10 months in pupal diapause. (Preserved = 1, 5, 6; photos = 1, 1c.) (2) W.AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. NNE of Geraldton (NM): Larvae (Sept.–Oct.) on young lvs. (only) of *Dryandra fraseri* R. Br. (det. WAH).

• *Hypographa hircopsis* Meyr. (det. SF)—G.240. W.AUST., Geraldton-Drummond Cove district (NM): Captive larvae (July–early Aug.) readily accepted the youngest new leaves (only) of *Grevillea pinaster* Meisn.—PROTEACEAE (det. NM); nocturnal feeders. Adults (B–) fly mid May–late June; univoltine. (Preserved = 1–6, 9; photos = 2, 5.)

• *Lissomma ampycteria* Turner (det. IC)—G.223. W.AUST., ± 2½ mi. S of Kalbarri, at Red Bluff Caravan Park (D. & NM): Larvae (mid–late Nov. 71) nocturnal feeders on tender young lvs. of the common "smoke bush," *Conospermum stoechadis* Endl.—PROTEACEAE (det. NM). An adult ♂ emerged Jan. 72. (Preserved = 1, 5, 6, 8d; photos = 5, 5c.)

• *Macrotenia ochripennata* (Walk.) (det. IC)—G.222. W.AUST., on the south coast at East Mt. Barren, ± 6 mi. W of Hopetoun (D. & NM): The original ♀ adult (23 Oct. 71) came to uv. light and was confined for eggs. The resulting larvae were reared at Red Bluff, nearly 700 mi. to the NW of the collection-site, where they accepted

young lvs. of *Conospermum stoechadis* Endl.—PROTEACEAE (det. NM). These larvae appear to have a fairly close kinship with *Oenochroma* spp. Adults fly Sept.–Nov.–?; probably univoltine. (Preserved = 1–5; photos = 4.)

● *Mictodoca ?toxeuta* Meyr. (det. IC)—W.VIC., Lowan Reserve, ± 5 mi. S of Kiata (NM): Larvae (28 Sept. 67) on *Baeckea behrii* (Schldl.) FvM.—MYRTACEAE (det. MK). Adults (1 ♂, 3 ♀) emerged early–mid April 68; probably univoltine. (Preserved = 1, 6.)

● *Monoctenia faleriaria* Gn. (det. IC, SF)—G.167. S.AUST., Blackwood (NM): Captive larvae (May–Sept.) readily accepted old and semi-mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B) fly March–April (peak mid–late March); univoltine. They come to uv. light almost without exception after 2300 hrs; ♀♀ hardly ever seen at lights. There is considerable variation in groundcolor and forewing maculation; the usual form here is predominantly light brown or tan, not pink-tinged. A photograph of a living adult ♂ of this sp., in its usual resting position, appears on the cover of *J. Res. Lepid.* 12(4), with data inside back cover. This moth and *Phallaria ophiusaria* (p. 46) are the two largest geometrids at Blackwood; a close third and fourth would be *Niceteria* (Ennominae) and *M. smerintharia* respectively. See McFarland (1972b: 235) for egg photos. (Preserved = 1–6, 9; photos = 1, 1c, 2, 4–6.)

● *Monoctenia smerintharia* Felder (det. IC, SF)—G.94 (a synonym is probably *calladelpha* Lower; type in S.A. Museum). S.AUST., Blackwood (NM): Captive larvae (May–Sept.) readily accepted mature (old) lvs. of *Eucalyptus leucoxylon* and *E. odorata* (dets. NM); reared on the latter. Adults (A) fly mid Feb.–early May (peak late March–early April); univoltine. The majority of ♀♀ (rarely seen at light) come in before 2300 hrs; most of the ♂♂ come in after 2300 hrs and are abundant at uv. light here. Differences in the ♂ & ♀ forewing coloration and maculation are notable in this sp.; most ♂♂ here are almost immaculate on the forewings and thorax. See McFarland (1972b: 235) for egg photos. (Preserved = 1–6, 9; photos = 1, ♂ 1c, 2, 5, 5c, 6.)

Nigasa—see *Arhodia*.

Oenochroma—see also *Macrotenia*.

● *Oenochroma vinaria* Gn. (det. IC, SF)—G.77, 77A, 77B, & 77C. (1) S.AUST., Blackwood-Belair district and Adelaide city and other suburbs (NM): Larvae (winter–early summer) on various eastern **Grevillea* spp. used commonly in gardens as ornamental shrubs and hedges; among these is also included the tree, silky-oak, **G. robusta* A. Cunn.—PROTEACEAE (det. NM). The “wild” populations in native scrub areas of the Belair district (as opposed to those in the city and suburban gardens), feed almost exclusively on tough-sclerophyll *Hakea* spp. (needle-bushes), esp. *H. rostrata* (det. NM), eating both old and young lvs., but preferring the latter when available. (I have never found them on the only native *Grevillea* of the Belair district, *G. lavandulacea*.) The older larvae often rest outstretched (lasiocampid or catocaline-style) along the lower woody or brown parts of stems, coming up to feed after dark. Adults (B+) recorded for all months (peaks Oct.–Dec., March–May, & late July); the majority (both sexes) come to uv. light after 2300 hrs. Both sexes are highly variable in ground color; less so in maculation. A washed-out print showing the usual resting position of an adult ♂ of this sp. as viewed from two different angles appears on the cover of *J. Res. Lepid.* 14(1), with comments on p. 60. See also Common (1966b: 81) and Tillyard (1926: Pl. 39) for ♂ adult photos; Common (1970: 849, fig. B) for illus. of final instar larva. (Preserved = 1–6, 9; photos = 1, 1c, 2, 5, 6.) (2) S.AUST., ± 8 mi. NE of Two Wells, on whitish sandhills (NM & TN): Larvae (20 Aug. 66) on *Grevillea ilicifolia* R. Br. (det. MK). (3) S.AUST., south coast of Kangaroo Is., ± 10 mi. W of Vivonne Bay (NM & G. D. Seton): Larva (10 Oct. 66) on the very tough old lvs. of *Hakea muelleriana* Black (det. MK); no new growth was present anywhere on the plant. (4) W.AUST., on the west coast, 21 mi. S of Lancelin (NM & N. B. Tindale): Larvae (9 Nov. 68) common, feeding on young lvs. and fls. of the common and widespread *Hakea trifurcata* (Sm.) R. Br. (det.

WAH). (5) W.AUST., ± 2 mi. NNE of Howatharra Hill Reserve, or ± 21 mi. NNE of Geraldton (D. & NM): Mature larvae (6 Oct. 74) on the fully-open fls. of *Hakea auriculata* Meisn. (det. WAH), very plump and feeding avidly; a few were also eating tender new lvs. where present, but the fls. were clearly preferred. (6) W.AUST., Moresby Ranges, Oakajee district, ± 16 mi. NNE of Geraldton (NM): Larvae (13 Oct. 74) on tender new lvs. of *Hakea lissocarpha* R. Br. (det. WAH).

• *Onychopsis lutosaria* (Felder) (det. NM)—G.219. VIC., Red Hill, south of Melbourne (eggs through D. R. Holmes; orig. ♀ 14 Feb. 70): Captive larvae (March–April 70) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM) at Blackwood, S. Aust. To my knowledge, this sp. has never been collected in the Mt. Lofty Range. Sexual dimorphism is notable; a good color illustration of the ♀ is given by Common (1966b: 72). (Preserved = 1–6, 9; photos = ♂ ♀ 1, ♂ 1c, 5, ♂ 6.)

Ophiographa—see *Dinophalus* and *Lissomma*.

• *Parepisparis* sp. (det. IC)—G.226. N.QLD., Atherton Tableland ($\pm 2500'$ el.) at Tinaroo Pines Caravan Park (NM & N. B. Tindale): The original ♀ adult (10 May 72) came to uv. light; eggs obtained. Captive larvae (late May–June 72) readily accepted young and semi-mature lvs. of *Eucalyptus ?polycarpa* FvM. (det. BH). Unfortunately, this rearing could not be completed, as we were leaving the locality in late June; the larvae refused other offered eucalypt lvs. that were encountered in transit, thus dying. (Preserved = 1–5.)

• *Phallaria ophiusaria* Gn. (det. IC, SF)—G.80. S.AUST., Blackwood-Belair district (NM): Captive larvae (June–Oct.) accepted mature lvs. of *Dodonaea viscosa*; I was told (by an eastern correspondent) that this was the only foodplant of *P. ophiusaria*, and so did not bother to offer them any of the other local native plants. They grew fairly well on the *Dodonaea*, but I have no evidence that they prefer it (or are ever to be found on it) in this habitat. On several subsequent occasions, however, larvae were collected at night (Sept., at Blackwood), feeding on tough mature lvs. of *Acacia pycnantha*, and during diurnal beating (July–Sept., at Belair) on tough mature lvs. (no new growth present on the shrubs) of *Hakea rostrata* (dets. NM). Relatively few of the “Macro” spp. normally feeding on *A. pycnantha* or *H. rostrata* will eat the very tough oldest lvs., a point of interest in the case of this moth. New lvs., in fact, do not normally begin to appear on *A. pycnantha* or *H. rostrata* until early spring (Sept.–Oct. \pm), by which time the *Phallaria* larvae have already been feeding and growing (very slowly) for 4–5 months. They are mostly in last instar by Sept.–Oct. in this locality. Adults (B) fly mid Feb.–late March (short peak in early–mid March only); univoltine. By far the majority of individuals come to uv. light after 2300 hrs; both sexes are about equally represented at light; if anything, ♀ ♀ come in more often than ♂ ♂ (the reverse of the usual situation). A moderate degree of variation is seen in the wing groundcolors (from ashy-gray to brown to pale tan). See McFarland (1972b: 237) for egg photos. (Preserved = 1–6, 9; photos = 1, 2, 5, 5c.)

• *Phrixocomes* sp., nr. *ptilomacra* Lower (det. NM)—G.157. S.AUST., south coast of Kangaroo Is., ± 10 mi. W of Vivonne Bay (NM & G. D. Seton): Larvae (19 Oct. 66) on *Melaleuca oraria* J. M. Black and *M. gibbosa* Labill.—MYRTACEAE (dets. MK); the former appears to be preferred in this locality. An adult ♂ emerged 4 Dec. 66. (Preserved = ♂ 1, ♀ 4, ♀ 5, 6; photos = ♂ 1.)

Rhynchopsota—see “*Chlenias*” *rhynchophora* Lower (Ennominae).

Miscellaneous Unidentified Oenochrominae

• ?*Dinophalus* sp. (det. NM)—G.224. W.AUST., on the west coast ± 3 mi. S of Kalbarri, nr. Red Bluff Caravan Park (D. & NM): Larvae (late Nov.–mid Dec. 71) feeding both day and night on young lvs. of *Grevillea ?trachytheca* (det. NM), and resting among the lvs. close to areas of feeding. No adults were successfully reared. (Preserved = 5, 6, 9; photos = 5.)

(E) SUBFAMILY STERRHINAE (SYN. = ACIDALIINAE)

- *Chrysocraspeda cruoraria* (Warren) (det. IC)—G.228. N.QLD., Atherton Tableland ($\pm 2500'$ el.), 12 mi. NE of Atherton, nr. Tinaroo Pines Caravan Park. (D. & NM): Captive larvae (June 72) readily accepted young and semi-mature lvs. of *Eucalyptus ?polycarpa* FvM. (det. BH). Completion of this rearing was not possible, as it was necessary to leave the locality in late June; the larvae died in transit. They were, however, thriving on the above eucalypt prior to departure. See Tillyard (1926: Pl. 39) for a ♂ adult photo of the closely-related *C. aurimargo* Warr. (Preserved = 1-4, 9.)
- *Eois (Idaea) costaria* (Walk.) (det. SF)—G.83; ?G.209. S.AUST., Blackwood (NM): Captive larvae (May-June) readily accepted buds and fls. of wireweed, **Polygonum ?aviculare* L.—POLYGONACEAE (det. NM); the lvs. were also accepted after about 3rd instar. Adults (A) fly \pm Oct.-May (peak Nov.-April). (Preserved = 1-6, 9; photos = 2, 5.)
- *Eois (Idaea) philocosma* (Meyr.) (det. SF)—G.197. S.AUST., Blackwood (NM): Captive larvae (Jan.-March 69) readily accepted lvs. and floral parts of **Polygonum ?aviculare* L. (det. NM). Adults (A) fly spring-autumn (peak Jan.). (Preserved = 1-6, 9; photos = 1, 2, 5, 6.)
- *Scopula (Acidalia) optivata* (Walk.) (det. SF)—G.198. S.AUST., Blackwood (NM): Captive larvae (Jan.-Feb. 69) readily accepted lvs. of **Polygonum ?aviculare* L. and bur clover, **Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars (dets. NM); of the two, the former was preferred. Adults (A) fly spring-autumn (peak Jan.). (Preserved = 1-6, 9; photos = 1, 2.)
- *Scopula (Acidalia) rubraria* (Dbldy.) (det. IC)—G.97. S.AUST., Blackwood (NM): Captive larvae (May-June) avidly accepted lvs. of the common lawn weed, plantain or ribwort, **Plantago lanceolata*—PLANTAGINACEAE (det. NM). Adults (A+) recorded for every month (peak Dec.-March); they rest by day among weeds and grasses, hanging from stems, etc., and are particularly common around weedy, uncut lawns. They are quick to take flight if approached in the daytime (flying low and only short distances), but could not really be considered diurnal in habit. (Preserved = 1-6, 9; photos = 1c, 5.)

Miscellaneous Unidentified Sterrhinae

- *Genus? sp.?*—G.229. N.QLD., Atherton Tableland, 16 mi. ESE of Mareeba, on a rocky ridge-top 6 mi. up Davies Creek Rd. (D. & NM): A single larva (4 June 72) on fl. buds of the shrubby *Acacia leptostachya* Benth. (det. L. Pedley). This most distinctive small larva could be mistaken for no other; unfortunately it died in the pupal stage. (Preserved = dry skin of 5, dried and shrunken 6, 7; photos = 5.)

IMMIDAE

- *Imma vaticina* Meyr. (det. IC)—N.QLD., Clifton Beach, ± 14 mi. N of Cairns (D. & NM): Larvae (9 May 72) on lvs. of the shrub, *Fenzlia obtusa* Endl.—MYRTACEAE (det. BH). Adults (♂, ♀) emerged 22 May 72; in A.N.I.C., Canberra. See also Common (1979: 36). (Preserved = 1, 6, 7.)

LASIOCAMPIDAE

- *Crexa acedesta* Turner (det. IC)—La.20. S.AUST., Blackwood-Belair district (NM): Captive larvae (March) readily accepted the pendulous mistletoe, *Amyema miquelii*, parasitizing *Eucalyptus odorata*; never on *Exocarpos* here (det. NM). Adults fly Feb.-March; rarely seen at uv. light. Sexual dimorphism is fairly notable. See Common (1966b: 89) for ♂ & ♀ adult photos. (Preserved = 1-7, 9; photos = 2, 2c, 3.)

• *Crexia punctigera* Walk. (det. IC)—La.16 (a synonym may be *Sitina anthraxoides* Walk., in B.M.N.H.). S.AUST., Blackwood-Belair district (NM): Larvae (Aug.–April) fairly common on the shrubby root-parasite, *Exocarpos cupressiformis* (det. NM). Adults fly spring–summer; rarely seen at uv. light here. Sexual dimorphism is notable. See Common (1966b: 89) for larval photo of this sp. at rest on *Exocarpos*. (Preserved = 1, 4–7, 8h, 9; photos = 6.)

• *Digglesia australasiae* (Fab.) (det. IC)—La.15. S.AUST., Blackwood-Belair district (NM): Larvae (most months of the year) on various shrubs, including *Acacia* spp. and (especially) *Exocarpos cupressiformis* (det. NM). Adults (A) fly most months, with peaks in March–April & July; both sexes frequent at u.v. light (especially after 2300 hrs). See Common (1966b: 91) or Tillyard (1926: Pl. 30) for ♂ adult photo. (Preserved = 1–6, 9; photos = 1, 2, 5c, 6.)

• *Digglesia rufescens* (Walk.) (det. SF)—La.18. S.AUST., Blackwood (NM): Captive larvae (Aug. & Jan.) readily accepted young lvs. of *Eucalyptus odorata* (det. NM). Adults (B) fly Dec.–Feb. & May–July, with peaks in Dec., Feb., & late June–early July; both sexes frequent at uv. light. See McFarland (1970: 349 & 1972b: 223) for egg photos. (Preserved = 1–7, 9; photos = 2, 5, 6.)

• *Entometa* sp. (det. NM)—La.14. S.AUST., Blackwood-Belair districts (NM): Larvae (spring–summer) on *Eucalyptus leucoxylon* and *E. odorata* (dets. NM). Adults (B) fly March–April (univoltine), esp. after 2300 hrs; both sexes come to uv. light. Coloration of ♂ & ♀ nearly identical in this species; forewings are pale tan and hindwings are pale orange. A distinguishing feature of this (very large) sp. is its dense and tough elliptical cocoon, the smooth outer surface of which is “dyed” bright green (by a fluid injected into the silk by the larva, during the early phases of cocoon-construction); inner cocoon-lining of silk is pure white, however. Regarding the “?” preceding the reared hymenopterous parasites cited below: These are presumed from another closely-related *Entometa* sp., which is the common one in the Adelaide city area, where these parasite cocoons were collected from a moribund mature larva at Collinswood, S.AUST., in a city garden (8 Dec. 66, Mrs. R. Smith). See Common (1966b: 91) for ♂ & ♀ adult photos probably of this sp.; see also Common (1970: 850). (Preserved = 1–7, ?8h, 9; photos = 7.)

Opsirhina—see *Digglesia*.

• *Perna exposita* (Lewin) (det. IC)—La.19. S.AUST., Blackwood-Belair-Eden Hills district (NM): Larvae (most months; peak Dec.–Feb.) on mature foliage of *Casuarina stricta* (det. NM). These larvae have only been collected on the tree, *C. stricta* in this locality, never on the shrubby *C. muelleriana* which I have beaten extensively (all seasons) in search of various larvae. Adults (B) fly spring–autumn; both sexes frequent at uv. light. See Common (1966b: 91) for ♂ adult photo. (Preserved = 1–7, 9; photos = 2, 5.)

• *Perna* sp. nov. (det. IC)—La.23. S.AUST., N. Flinders Ranges, 3½ mi. S of Arkaroola Homestead, at roadside (NM): Larvae (30 Oct. 69) on *Casuarina* sp. (a tree). The adult is somewhat larger than *P. exposita* and very much paler, with only faint (pale tan) maculation on the whitish forewings. (Preserved = 1, 5.)

• *Pinara ?cana* Walk. (det. SF)—La.22. S.AUST., Belair, Gloucester Ave. at Ralph St. (A. Kowanko): Captive larvae (Sept. 69) readily accepted young lvs. of *Eucalyptus odorata* (det. NM). Adults fly late winter–autumn; rarely seen at uv. light here. Sexual dimorphism is notable. See Common (1970: 850) for ♂ adult photo of *P. cana*. (Preserved = 1–7; photos = 2, 6.)

• *Porela galactodes* (Lower) (det. IC)—N.QLD., Atherton Tableland, 12 mi. NE of Atherton, nr. Tinaroo Pines Caravan Park ($\pm 2500'$) (D. & NM): Larva (late March 72) on small sapling of the tree, *Casuarina littoralis* Salisb. (syn. = *C. suberosa*) (det. BH). A deformed adult ♂ emerged 16 June 72; in A.N.I.C., Canberra. (Preserved = ♂ 1, 5 head capsule only, 6, 7.)

Sitina—see *Crexia*.

LIMACODIDAE

• *Calcarifera ordinata* (Butl.) (det. IC)—Lm.7. (1) W.AUST., Moresby Range, ± 15 –20 mi. NNE of Geraldton, in the Oakajee-Howatharra district: Gaudy larvae (Aug.–mid Oct.) abundant (most years) on 3 spp. of small, low-growing shrubby acacias here: *Acacia ericifolia* Benth., *A. oxyclada* F. Muell. ex Benth., and *A. ulicina* Meisn. (dets. B. R. Maslin). These acacias all have small, narrow (linear) phyllodes. *C. ordinata* larvae are sometimes so common (locally) as to defoliate their foodplants; they make no attempt to hide at any time and are most conspicuous. Adults fly mid Feb.–early April (\pm); sexes similar in appearance; univoltine. (2) W.AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. NNE of Geraldton (McFarland, 1977: 19): The preferred foodplant, in this specific locality, seems to be *Acacia ulicina*, but *A. ericifolia* is also frequently eaten; *A. oxyclada* is not present on the reserve. (Preserved = 1, 4–7, 9.) Other records from Howatharra Hill Reserve: 25 Aug. 77 (NM), one last instar seen feeding on tough, mature stems(!) of *Brachysema aphyllum* Hook.—FABACEAE (det. NM); 17 Sept. 77 (NM), 2 last instars feeding on old (tough) lvs. of *Gastrolobium oxylobioides* Benth. (Champion Bay Poison Bush!)—FABACEAE (det. NM), in Zone 3 (SW); 25 Aug. 77 (NM), 2 last instars on mature (tough) phyllodes of *Acacia acuminata* in Zone 5 (WC) and 2 feeding on a low, shrubby, “broom-like” *Jacksonia* sp. (NM.1175)—FABACEAE, in Zone 4 (C); 28 Sept. 77 (NM), one last instar feeding on leathery, mature phyllodes of *Acacia ?saligna* Wendl. (det. NM), in Zone 5 (NE). (3) W.AUST., Northampton, on Lot 351 (Wannere-nooka Rd.). Larvae (L5–1 Sept. 77) abundant on *Acacia tetragonophylla* F. Muell. (det. NM).

• *Doratifera oxleyi* (Newman) (det. IC)—Lm.5. S.AUST., Blackwood (NM): Larvae (July–Oct.) abundant on mature lvs. of *Eucalyptus odorata* (det. NM); young larvae scar the lf. surfaces with their characteristic “feeding-grooves.” (But see also the zygaenid, *H. tricolor*.) Adults (A+) fly March–April only; ♀♀ abundant at uv. light, but ♂♂ rarely come to uv. light; univoltine. Peak of ♂ activity probably diurnal (from ± 1000 –1500 hrs). Sexual dimorphism is striking in this moth. See Common (1966b: 67) for ♂ & ♀ adult photos; Tillyard (1926: Pl. 30) for ♂. See McFarland (1970: 349 & 1972b: 219) for egg photos. (Preserved = 1–3, 5–7, 8dhh, 9; photos = 2.)

• *Doratifera quadriguttata* Walk. (det. SF, IC)—Lm.4. S.AUST., Blackwood (NM): Larvae (Jan.–Feb.) on mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B+) fly Nov.–early Feb. (peak Dec.); sexes similar in appearance and both nocturnal; univoltine. (Preserved = 1–5, 9; photos = 2.)

• “*Parasa*” sp. (det. IC)—Lm.6. W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (NM): Captive larvae (summer) readily accepted mature and semi-mature lvs. (phyllodes) of the dominant shrub or low tree of this locality, *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). Adults (B+) fly Nov.–early April (peak Dec.–Feb.); multiple-brooded; sexes similar in appearance and both nocturnal; ♀ rarely taken at uv. light here. Egg very reminiscent of the *Pseudanapaea trigona* egg. (Preserved = 1–7, 9.)

• *Pseudanapaea trigona* (Turner) (det. IC)—Lm.3 (a synonym may be *P. dentifascia* Hering, in B.M.N.H.). S.AUST., Blackwood (NM): Larvae (early spring–autumn) on mature lvs. of *Eucalyptus odorata* (det. NM). Adults (A) fly Oct.–May (peaks Nov.–Dec. & Feb.–April); multiple-brooded; sexes similar in appearance and both nocturnal. The egg is most distinctive with a very soft and entirely transparent chorion. See McFarland (1970: 349 & 1972b: 219) for egg photos. (Preserved = 1–6, 9; photos = 1–3, 5–7.)

LYMANTRIIDAE

• *Acyphas leucomelas* (Walk.) (det. IC)—Lp.8, 8A, 8B, & 8C. (1) S.AUST., Blackwood-Belair district (NM): Larvae (Aug.–Oct.) abundant on young lvs. of

Acacia pycnantha (det. NM). Although they eat only the young lvs., they usually rest well down the stems on reddish-brown scarred (or partly-damaged and twisted) mature phyllodes, where their colorful maculation renders them surprisingly inconspicuous. Also (less often) found on a variety of other plants, some specific records being *Acacia armata*, *Pultenaea largiflorens* var. *latifolia*, *Exocarpos cupressiformis*, *Dodonaea viscosa*; also *Myoporum viscosum* R. Br.—MYOPORACEAE and *Eucalyptus odorata* (dets. NM). Adults (A) fly Oct.–Dec. & Feb.–April; sexes similar in appearance and both come to uv. light. See Common (1966b: 107) for ♂ adult photo of this or a closely-related sp. (Preserved = 1–6, 8h, 9; photos = ♀ 1c.) (2) S. AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, on land of G. D. Seton (NM): Larvae (mid Oct. 66) on the low, rounded, “broom-like” root-parasite, *Choretrum glomeratum* R. Br.—SANTALACEAE (det. MK); also on new lvs. of *Platylobium obtusangulum* Hook.—FABACEAE (det. NM). (Preserved = 5.) (3) W. AUST., at Lot 68, Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Larvae (most months, but especially Aug.–March) abundant and conspicuous on *Acacia ligulata* A. Cunn. ex Benth. (det. NM); usually on rather thick mature phyllodes, rasping the surfaces, or partially eating in from the edges. Often on low, dense, windblown specimens of *A. ligulata* along the slopes and ridges of the sandhills, close to the beach. This population may be a distinct subspecies of the eastern *leucomelas*. (Lp.8C: preserved = 1, 5–7, 8ddhh, 9.)

Euproctis aliena Butler (Type in B.M.N.H.)—see synonym, *A. leucomelas* (Walk.).

• *Euproctis marginalis* (Walk.) (det. IC)—Lp.11. S.AUST., Blackwood (NM): Captive larvae (Dec.–Jan.) accepted mature lvs. of *Eucalyptus odorata* (det. NM). Nocturnal feeders, probably hiding under loose bark by day. Adults (A) fly Nov.–Jan. (♀ ♀ mostly not before late Dec.); sexes similar in appearance and both nocturnal; ♀ ♀ to uv. light mostly before 2300 hrs and ♂ ♂ mostly after; univoltine. See Common (1966b: 107) for ♀ adult photo of a closely-related sp. (Preserved = 1–5, 9; photos = 1.)

• *Habrophylla euryzona* (Lower) (det. IC)—Lp.12. (1) S.AUST., south coast of Kangaroo Is., at Seal Bay (NM, M. Pate, & G. D. Seton): Mostly fullgrown larvae (16 Oct. 66) exceedingly common, crawling over the sand in association with larvae of my An.6A (Anthelidae) and Ar.34A (Arctiidae); seen eating various low-growing annual winter herbs (ephemerals), as follows: *Crassula* sp.—CRASSULACEAE; *Daucus glochidiatus* (Labill.) Fisch., Mey., & Avé-Lall., and *Hydrocotyle* sp.—both APIACEAE (dets. MK). Adult ♂ ♂ probably fly from late Oct.–early Nov.; univoltine. The ♂ is diurnal, with a peak of activity in mid to late afternoons of sunny, still days, according to the late J. O. Wilson (pers. comm.). Sexual dimorphism in this sp. is stupendous! The ♀ is wingless and highly degenerate. (Preserved = ♂ ♀ 1, 2, 4–♂ ♀ 6, 7, 8dh, 9; photos = ♂ 1.) (2) S.AUST., on coast S of Adelaide, Normanville dunes (NM & Mr. & Mrs. J. O. Wilson): Small to half-grown larvae (26 May 69) abundant, crawling over the dune sand, mostly nr. or under shrubs, where they were resting and feeding on the small to very small (recently-germinated) seedlings of winter annuals (various unidentified plant spp. involved).

• *Orgyia anartoides* (Walk.) (det. IC)—Lp.9. S.AUST., Adelaide city & suburbs, and Blackwood (NM): Larvae (most seasons, but especially winter) on many woody plants. Specific examples: *Acacia pycnantha*, *Hardenbergia violacea*, *Exocarpos cupressiformis*, **Betula* sp. (birch)—BETULACEAE, and the semi-woody, orange-flowered **Lantana* sp.—VERBENACEAE (dets. NM). The moth is more common in city & suburbs (garden situations) than in relatively undisturbed areas where the native flora still predominates. Adult ♂ ♂ (♀ degenerate & wingless) fly in spring–summer (B– at Blackwood). Sexual dimorphism is spectacular, very similar to the North American tussock moths (*Hemerocampa*). (Preserved = 1, 4–7, 9.) See Common (1966b: 105, 107) for ♂ & ♀ adult photos and probably the larva; Tillyard (1926: Pl. 30) for ♂ adult).

NOCTUIDAE

- *Achaea janata* (L.) (det. NM)—N.125. W.AUST., Exmouth Gulf district (North West Cape), in the low, coastal sandhills immediately SE of Norcape Lodge; also in a similar situation ± 10 –12 mi. S of Exmouth P.O. (D. & NM): Eggs and larvae of various sizes (7 July 77) on 3 common, low-growing, annual euphorbias, *Chamaesyce sharköensis* (Baillon) Hassall ms., *C. australis* ssp. *glaucescens* (Boiss.), and *C. coghlanii* (F. M. Bail.) Hassall—EUPHORBIACEAE (det. D. Hassall, 1978). The locality had had one major rain about mid-late May; by early July most annuals were rapidly maturing (flowering and setting seed). These large, dark larvae made little attempt to hide and were thus very conspicuous on their foodplants when full-grown; when small, their dark frass on the fine, white sand was an obvious clue. By mid July all had pupated; adults emerged Aug. 77. See Common (1966b: 117) for adult photo. (Preserved = 1, 6.)
- *Aedia acronyctoides* (Gn.) (det. NM)—N.96. S.AUST., Blackwood-Eden Hills district (NM): Larvae (Oct. & Jan.) on open, grassy-rocky slopes, on Australian bindweed, *Convolvulus erubescens* Sims.—CONVOLVULACEAE (det. MK). Adults (B–) fly Oct.–April (peaks Nov. & Jan.–Feb.). See Common (1966b: 119) for adult photo. (Preserved = 1, 5, 9.)
- *Anomis flava* (Fab.) (det. IC)—N.121. N.QLD., Atherton Tableland, Atherton, at the Forestry Regional Research Station (A. Irvine): Larvae (April 72) abundant on *Hibiscus diversifolius* Jacq.—MALVACEAE (det. BH). (Preserved = 1, 5, 6, 8d.)
- *Buciara bipartita* Walk. (det. IC)—N.94. S.AUST., Blackwood-Belair districts (NM): Larvae (July–early Sept.) nocturnal feeders on new growth of *Hibbertia exutiacies*, *H. sericea*, and *H. stricta* (dets. MK). Adults (B+) fly late Nov.–mid May (peaks Dec. & April); coming to u.v. light mostly after 2300 hrs, rarely before. (Preserved = 1, 2, 4–7, 9; photos = 1, 2.)
- *Calathusa ischnodes* (Turner) (det. IC)—S.AUST., Aldinga, in \pm virgin bushland area (Mr. & Mrs. J. O. Wilson): Larvae (April 67) on *Casuarina striata* Macklin. (det. J. O. Wilson). Adult (emerged Oct. 67) in the late J. O. Wilson's collection, which has recently gone to the A.N.I.C., Canberra. (Preserved = 1, 6.)
- *Callopietria maillardi* Gn. (det. IC, SF)—N.118. N.QLD., Atherton Tableland, at Tinaroo Pines Caravan Park ($\pm 2500'$ el.) (D. & NM): Larvae (April–June 72) in garden on young and semi-mature lvs. of the ornamental fern, **Nephrolepis pteridifolia* (var. ?)—POLYPODIACEAE (det. by Limberlost Nursery, Cairns). I am indebted to IC for the specific det. and to SF for the generic placement. (*Eriopus Treitschke*, 1825, is a junior objective synonym of *Callopietria* Hübner, 1821.) It is of interest to note that the living larvae of 3 Japanese *Callopietria* spp. are depicted (with photographs) on various ferns by Mutuura et al. (1970: Pl. 32, figs. 97–99); of the spp. they figure, *C. juvenina obscura* Butler is fairly close in appearance to *C. maillardi* (especially the adult). (Preserved = 1, 5, 6, 9.)
- *Canthylidia zorophanes* Turner (det. IC)—N.123. W.AUST., beach areas of Drummond Cove, ± 7 mi. N of Geraldton (NM): Larvae (Sept.–Oct.) abundant, mostly on the staminate (σ) fls. of the conspicuous beach grass, *Spinifex longifolius* R. Br.—POACEAE (det. NM). Adults (A) fly autumn–spring (peak winter). (Preserved = 1, 5, 6.)
- Catephia*—see *Aedia*.
- Corrha*—see *Praxis*.
- *Cremnophora angasi* Walk. (det. NM)—N.116. S.AUST., ± 10 mi. NW of Tintinara, at roadside (TN): Larvae (mid Sept. 69) conspicuous on the low-growing *Halgania cyanea* Lindl.—BORAGINACEAE (det. MK). Reared adult in Newbery Collection. (Preserved = 5.)
- *Dasypodia selenophora* Gn. (det. NM)—N.100. S.AUST., Mt. Lofty Range, Stirling West (NM): Captive larvae (Nov.) readily accepted young lvs. of *Acacia*

pyncantha (det. NM). Adults recorded for most months except winter. See Common (1966b: 119) for adult photo. (Preserved = 1-3, 5, 6, 8d, 9.)

• *Diatenes igneipicta* (Lower) (det. IC)—S.AUST., 5 mi. E of Two Wells (NM): Larva (19 March 67) beaten from *Acacia ligulata* A. Cunn. ex Benth. (det. MK). Adult emerged 12 Dec. 67. (Preserved = 1, 6, 7.)

• *Donuca spectabilis* Walk. (det. IC)—N.115. W.AUST., Drummond Cove, \pm 7 mi. N of Geraldton (D. & NM): Captive larvae (Dec. 72) readily accepted lvs. (phyllodes) of *Acacia ligulata* A. Cunn. ex Benth. (det. B. Maslin). Adults (B-) fly spring-summer. (Preserved = 1-6, 9.)

• *Earias huegeli* Rog. (det. IC)—N.117. W.AUST., 2 mi. S of Kalbarri, Red Bluff Caravan Park (D. & NM): Larvae (early Nov. 71) on and inside buds, fls., & green seed capsules of the shrub, *Alyogyne hakeifolia* (Giord.) Alef.—MALVACEAE (det. WAH). Adults fly spring-summer. See Common (1970: 863) for adult photo. (Preserved = 1, 3-7, 8d, 9.)

Eriopus—see *Callopietria*.

• *Eublemma glaucochroa* Turn. (det. IC)—N.120. N.QLD., Atherton Tableland, nr. Tinaroo Pines Caravan Park (\pm 2500' el.) (NM): Larvae (April 72) in "fuzz-nests" on lvs., and in lf. buds and growing tips of the weedy-herbaceous *Pterocaulon sphacelatum* Benth. & Hook.—ASTERACEAE (det. BH). (Preserved = 1, 5, 6, 8h, 9.)

• *Euplexia dolorosa* (Walk.) (det. IC)—N.119. N.QLD., Atherton Tableland, nr. Tinaroo Pines Caravan Park (\pm 2500' el.) (NM): Larvae (April 72) on lvs. of *Pterocaulon sphacelatum* Benth. & Hook. (det. BH), and *P. glandulosum* Benth. & Hook. (det. NM)—ASTERACEAE. The former appears to be preferred in this locality. (Preserved = 1, 5, 6, 8d, 9.)

Istarva—see *Sandava*.

Liocola—see *Paracrama*.

Maurilia—see *Paracrama*.

• *Meyrickella torquesaria* (Lucas) (det. IC)—N.QLD., Atherton Tableland, 8 mi. E of Mareeba, along rd. to Kuranda (D. & NM): Larva (4 June 72) and pupa (in cocoon) on native "pine," *Callitris columellaris* ssp. *intratropica* R. T. Bak.—CUPRESSACEAE (det. I. Telford). The superb adult ♂ emerged 12 June 72. (Preserved = 1, 5, 6.)

• *Neumichtis saliaris* Gn. (det. SF)—N.104. S.AUST., Blackwood (NM): Captive larvae (Sept. 66) readily accepted the annual bur clover, **Medicago polymorpha* var. *vulgaris* (Benth.) Shinnars (det. NM)—FABACEAE. Adults (B) fly spring-summer. (Preserved = 1-6.)

• *Nitocris callimera* (Lower) (det. IC)—N.114. (1) W.AUST., south coast at Eucla ghost town, on white sand dunes (NM & N. B. Tindale): Larvae (Oct.-Nov. 68) always under the sand, usually under or near the bases of small woody shrubs, where they remain by day. They feed on (unidentified) plant parts, which are just under the drifting, windblown sand. Several of the common plants of this habitat probably serve as food. Undoubtedly involved are certain shrubs in the CHENOPODIACEAE; possibly also grasses. The larvae wander about at night, always sub-surface, leaving concave, meandering trails (grooves) in the sand, reminiscent of the common and conspicuous trails made by certain abundant wandering antlion larvae of this same habitat (Neuroptera: Myrmeleontidae: *Acanthaclisus* spp.). Adults emerged after a period of hot days in Jan.-Feb. 69; probably univoltine. (Preserved = 1, 4-6, 8dd, 9.) (2) S.AUST., west coast of Eyre Peninsula, nr. Elliston, on white sand dunes (D. & NM): Larvae (16 Oct. 71) abundant under conditions almost identical to above; fresh (soft), green frass was under the sand with the resting larvae. Plants involved not identified.

• *Omphaletis norologa* (Meyr.) (det. NM)—N.103. S.AUST., \pm 8 mi. NE of Two Wells, around borders of sandhills; also nr. Kangaroo Flats, in similar habitat (NM & TN): Larvae (20, 27 Aug. 66) on the shrub, *Rhagodia parabolica* R. Br.—CHENO-

PODIACEAE (det. MK). Extremely abundant (by beating); preferred are more dense or compact individuals of the foodplant, especially those in close contact with the ground. (Preserved = 1, 4-7, 9.)

● *Pantylia ?capistrata* Lucas (det. IC)—W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (NM): Larva (May 73) feeding at night on *Acacia ligulata* (det. B. R. Maslin). Adult emerged 5 Aug. 73. (Preserved = 1, 6.)

● *Pantylia sparsa* Gn. (det. IC)—S.AUST., Yorke Peninsula, nr. Cunliffe (NM, N.B. Tindale, & P. Aitken): Larva (early Nov. 65) on the shrubby root parasite, *Exocarpos aphyllus* R. Br. (det. MK). Adult emerged late Nov. 65. See Common (1966b: 119) for adult photo. (Preserved = 1, 6, 7.)

● *Paracrama iocephala* (Turner) (det. IC, SF)—N.108. S.AUST., Adelaide city & suburbs, especially at Hurtle Square and on the Adelaide Univ. campus (NM): Larvae (Nov.-June) locally abundant on the N.S.W.-Qld. trees (planted here as ornamentals).

**Lagunaria patersonii* G. Don.—MALVACEAE, and kurrajong. **Brachychiton populneum* R. Br.—STERCULIACEAE (dets. MK). Adults (B) probably fly most months, except midwinter; rare at Blackwood. (Preserved = 1, 4-7, 8h, 9; photos = 1, 6.)

● *Plusia ?argentifera* Gn. (det. SF)—N.101 (possibly = *subsicens* Walk.). S.AUST., Adelaide city, at S.A. Museum (NM): Larvae (late May) defoliating ornamental geraniums, **Pelargonium* sp.—GERANIACEAE (det. NM), growing in window-boxes. (Preserved = 1, 4-7, 8h, 9; photos = 5, 6.)

● *Praxis alterrima* (Walk.) (det. IC)—N.102. (This may = synonym of the Lower ms. name, "*Corrha pandesma*.") S.AUST., Eden Hills, Yalanda St. (orig. ♀ from G. Furness): Captive larvae (Aug.-Sept.) readily accepted new lvs. of *Acacia pycnantha* (det. NM). Adults (B+) fly late May-Aug. (peak July); univoltine. (Preserved = 1-7, 9.)

Proteuxoa—see *Omphaletis*.

● *Sandava scitisignata* Walk. (det. SF)—N.97. (1) S.AUST., Blackwood (NM): Captive larvae (Nov. 65) readily accepted and completed growth upon fresh commercial mushrooms, **Psalliota arvensis* Schaeff. ex Secr.—AGARICACEAE, s.s. (det. MK). Adults (B-) fly late Sept.-early May (peaks Oct., March), coming to u.v. light esp. after 2300 hrs. (Preserved = 1-5, 9; photos = 1, 2.) (2) S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay (NM): One larva (1 Jan. 66) found under loose bark of a dying *Eucalyptus* sp. (probably eating fungi, or fungal mycelia, which were present on this tree trunk).

Adults of this sp. have also been taken at u.v. light at Drummond Cove, W.AUST., ± 7 mi. N of Geraldton (uncommon).

● *Spodoptera litura* (Fab.) (det. IC)—W.AUST., Geraldton (NM): Larva (Oct. 73) on tree tobacco, **Nicotiana glauca* Grah.—SOLANACEAE (det. NM): the record is of interest because nothing else has been observed feeding on this common weed here. Adult emerged 25 Nov. 73 at 2140 hrs. (Preserved = 1, 6.)

NOLIDAE

● *Aquila tactalis* (Walk.) (det. IC)—N.18 & 8A. (1) W.AUST., $2\frac{1}{2}$ mi. S of Kalbarri, Red Bluff Caravan Park (D. & NM): Captive larvae (Nov. 71) readily accepted young lvs. of the locally abundant shrub, *Melaleuca megacephala* F. Muell.—MYRTACEAE (det. WAH). Made typical nolid cocoons of bark surface splinters chewed off the foodplant stem and woven together from the inside. Adults fly spring-summer-? (Preserved = 1-7, 9.) (2) S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, around shore of a small, freshwater lagoon (NM & G. D. Seton): Larva (mid Oct. 66) on mature lvs. of a tough, dwarfed individual of the shrub, *Melaleuca gibbosa* Labill.—MYRTACEAE (det. MK). See Common (1970: 863) for adult photo. (Preserved = 5, 9.)

Celama—see *Nola*.

Coesa—see *Uraba*.

- *Nola bifascialis* (Walk.) (det. IC)—N.QLD., Clifton Beach, ± 14 mi. N of Cairns (D. & NM): Larva (9 May 72) on the shrub, *Fenzlia obtusa* Endl.—MYRTACEAE (det. BH). Adult (δ) emerged 30 May 72. (Preserved = 1, 6, 7.)
- *Nola eurrhyncha* Turner (det. IC)—Nl.4. S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, around shore of a small, freshwater lagoon (NM & G. D. Seton): Larvae (13 Oct. 66) on *Melaleuca gibbosa* Labill. and *M. oraria* J. M. Black—MYRTACEAE (dets. MK). The former appears to be the preferred foodplant in this locality. (Preserved = 1, 5–7, 9.)
- *Nola ?lechriopa* Hamps. (det. IC)—Nl.6 & 6A. S.AUST., Mt. Lofty Range, nr. Upper Sturt (TN): Larva (24 Sept. 67) beaten from *Astroloma conostephioides* (det. TN). Another record (the same species), beaten from the same foodplant, nr. Norton Summit (also Mt. Lofty Range), coll. by R. Briggs. (Preserved = 1, 5–7.)
- *Nola ?parallacta* Meyr. (det. IC)—Nl.3 & 3A. S.AUST., Yorke Peninsula, ± 2 mi. S of Kainton (NM, N. B. Tindale, & P. Aitken): Larvae (4 Nov. 65) on the pubescent undersides of lvs. of the small, open shrub, *Olearia pannosa* Hook. (det. MK). (Preserved = 1, 4–7, 9; photos = 1c.) (2) S.AUST., nr. Melrose, on Mt. Remarkable at 2400' el. (H. M. Cooper): Larvae (24 Sept. 66) on a broad-leaved form of *O. pannosa* (det. MK). (Preserved = 5.)
- *Nola* sp. (det. NM)—Nl.7. S.AUST., Blackwood (NM): Larva (10 Sept. 67) on the semi-woody dwarf shrub, *Pultenaea largiflorens* var. *latifolia* (det. MK). Preserved = 5.)
- *Nola* sp. (det. NM)—W.AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. NNE of Geraldton (NM): Larva (Nov. 1977) on dormant, immature fl. buds of *Astroloma serratifolium* (DC.) Druce (det. WAH). Adult H. 2 Dec. 1977. (Preserved = 1, 6, 7.)

Roeselia—see *Uraba*.

- *Sorocostia hesycha* Meyr. (det. IC)—W.AUST., Drummond Cove sandhills (nr. beach), ± 7 mi. N of Geraldton (NM): Larvae (May 73) on lvs. of *Olearia axillaris* (DC.) F. Muell. (det. WAH). Adult emerged 4 June 73. (Preserved = 1, 6.)
- *Uraba lugens* (Walk.) (det. SF)—Nl.2. S.AUST., Blackwood (NM): Larvae (July–Oct. & Jan.–Feb.) locally abundant on mature lvs. of peppermint gum, *Eucalyptus odorata* (det. NM). The smaller larvae are gregarious and skeletonize the lvs. in a characteristic way. In some years these larvae are so abundant as to nearly defoliate some of the trees in this locality. (Also on many other *Eucalyptus* spp.). Adults (A+) fly Oct.–Dec. & late Feb.–April. This sp. deposits its eggs in groups of almost perfectly parallel, separated rows. See Tillyard (1926: Pl. 39) for δ adult photo; McFarland (1972b: 229) for egg photos. (Preserved = 1, 2, 4–7, 9; photos = 1, 2, 5, 7.)
- *Unidentified large nolid* (det. NM)—Nl.5. S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, on the property of G. D. Seton, at the edge of a small freshwater lagoon (NM & M. Pate): 3 larvae (mid Oct. 66) on tough, dwarfed individuals (only!) of *Melaleuca gibbosa* Labill.—MYRTACEAE (det. MK). After return to the mainland, all 3 larvae died; thus no adults were obtained. This record is included primarily because of the very large size and unique appearance of these larvae. There are only one or two described nolids that it could be (due to the large size), and the larvae are most distinctive in morphology and coloration. It was apparently uncommon in this locality, as several hours of beating exclusively *M. gibbosa* were required to obtain 3 larvae. (Preserved = 5, 9.)

Zia—see *Aquila*.

NOTODONTIDAE

(see also Thaumetopoeidae)

- *Antimima corystes* Turner (det. IC)—Nd.18. W.AUST., in Kalbarri National Park, ± 22 mi. E of Kalbarri township, nr. north side of road (NM & N. B. Tindale): Mature larvae (6 Nov. 68) on young tender tips of the low, rounded, intricate and spiny perennial, *Daviesia hakeoides* Meisn., s.l.—FABACEAE (det. A. Weston). This exact locality revisited 19 Nov. 71 (D. & NM); apparently too late, no larvae found

after 30 min of searching, but there were signs of fairly recent feeding on the newer stem tips and spine-lvs., which were already "hardening off" for the approaching hot and dry summer. Probably univoltine. (Preserved = 1, 5-7, 9; photos = 1.)

● *Antimima cryptica* Turner (det. IC, SF)—Nd.19, 19A, & 19B. (1) W.AUST., \pm 60 mi. SW of Three Springs, on a hill nr. the Hill R. (NM & N. B. Tindale): Larvae (8 Nov. 68) on soft young lvs. and stem tips of the spiny, prostrate and sprawling, semi-woody shrub, *Jacksonia furcellata* (Bonpl.) DC.—FABACEAE (det. WAH). (Note: Specimens of this same plant det. as *J. spinosa* (Labill.) R. Br., by plant taxonomists at Kings Park, Perth). (Preserved = 1, 5, 6.) (2) W.AUST., Darling Range, \pm 25 mi. ESE of Lancelin, nr. the Moore R. (NM & N. B. Tindale): Larva (9 Nov. 68) on the small, spiny, upright dwarf shrub, *Jacksonia ?sericea* Benth. (det. WAH). (3) W.AUST., Mt. Barren Range, \pm 6 mi. W of Hopetoun, on top of a rocky ridge (NM & N. B. Tindale): Larvae (26 Nov. 68) of all sizes (mostly penult. & last instars) abundant on the upright and leafy shrub, *Jacksonia compressa* Turcz. (det. WAH). Probably univoltine. (Preserved = 1, 2, 5, 6, 9; photos = 1, 5.) (4) W.AUST., 2 mi. S of Kalbarri, nr. Red Bluff Caravan Park (D. & NM): Larva (25 Nov. 71) on the rounded, upright, soft and broom-like, greyish-green shrub, *Jacksonia ?lehmannii* Meisn. (det. NM).

● *Commonia* sp. nov. (det. IC)—Nd.21. S.AUST., \pm 1.5 mi. E of Nundroo (B. & M. S. Moulds): A single penultimate instar larva (29 Sept. 78) found on *Melaleuca ?oraria* J. M. Black (det. NM). Mr. Moulds kindly gave me this colorful small larva during a visit to Drummond Cove, W. Aust.; after its final moult it readily switched to an offered substitute foodplant, *M. uncinata* (mature lvs.), upon which it completed growth without difficulty; fullgrown by 13 Oct. 78 (length 25 mm.); pupated Oct. 17th; adult emerged 2 Nov. 78, at \pm 2315 hrs; deposited in A.N.I.C. (Preserved = δ 1, 6, 9.)

● *Danimia banksiae* (Lew.) (det. NM)—Nd.15, 15A, 15B, 15C, 15D, & 15E. (1) S. AUST., Mt. Lofty Range, in Belair Nat. Park, 1 mi. E of Belair railway station (NM): Larvae (24 March 67) on tough mature (sclerophyll) lvs. of the dense woody shrubs, *Hakea rostrata* and *H. rugosa* R. Br. (det. MK). The former is the primary foodplant in this locality. Adults (B-) fly July-April \pm (?) (peak Aug.-Sept.). See Common (1966b: 103) or Tillyard (1926: Pl. 39) for δ adult photo; Common (1970: 858) for line drawing of penultimate instar larva; McFarland (1970: 349 & 1972b: 225) for egg photos. (Photos = 5c.) (2) S.AUST., Eyre Pen., 10-15 mi. N of Minnipa (C. J. Winn): Fullgrown larva (16 Sept. 66) on mature (tough-sclerophyll) lvs. of the woody shrub, *Hakea franciscana* FvM. (det. MK). (3) S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, in dense scrub nr. a freshwater lagoon (NM & G. D. Seton): Eggs (large and pure chalk-white; very conspicuous) and larvae (mid Oct. 66) of all instars (mostly small), abundant on tough, old (sclerophyll) lvs. of *Hakea muelleriana*; also a single larva on old lvs. of the woody, sclerophyll shrub, *Banksia ornata* FvM. ex Meisn. (dets. MK). Although *Banksia* is abundant in this locality, *Hakea* is apparently (by far) the preferred foodplant here. Revisiting this same locality in early Sept. 67, with Dr. E. C. Jaeger, I found fresh adults on the wing in moderate abundance, coming to uv. light. (Preserved = 1-6, 8h ex egg, 9; photos = 2.) (4) S.AUST., Mt. Lofty Range, nr. Hahndorf (TN): 5 penult. instar larvae (6 Dec. 66) on old lvs. of the woody sclerophyll shrub (or small tree), *Banksia marginata* (det. NM). (Photos = 5.) (5) S.AUST., inland red-sandy semi-desert, 72 mi. S of Kulgera (N.T.), in a dry creek bed (NM, TN, & L. C. Masterman): 3 eggs (25 May 67) attached to the long, linear, silvery-gray-pubescent, mature lvs. of a tree (drooping growth-habit; fls. small & cream-white), probably a *Grevillea* (det. NM). See also McFarland (1973: 202). (Preserved = 1, 2, 5, 6; photos = 5.) (6) W. AUST., 11 mi. SW of Three Springs (NM & N. B. Tindale): Larva (8 Nov. 68) on tough mature lvs. of the dense and woody sclerophyll shrub, *Dryandra cirsioides* Meisn.—PROTEACEAE (det. NM). (Preserved = 5.) (7) W.AUST., Moresby Ranges, Oakajee-Howatharra district, \pm 15-20 mi. NNE of Geraldton (NM): Larvae (Aug.-

early Oct.) frequent on *Hakea trifurcata* (Sm.) R. Br.; less often on *Grevillea pinaster* Meisn. (dets. NM).

• *Gallaba stenoptera* Turner (det. IC)—“N.” 98. S.AUST., SW Yorke Peninsula, ± 5 mi. SW of Carribe Homestead (NM, N. B. Tindale, & P. Aitken): The rather noctuiform green larvae (2 Nov. 65) were obtained by beating the densely-leafy, large evergreen shrub, *Leucopogon parviflorus* (Andr.) Lindl.—EPACRIDACEAE (det. MK). Probably univoltine. (Incorrect field identification of these larvae originally caused me to catalog them with the noctuids in my larval collection and notes, thus the “N.” code-number; the adult determination was not obtained until 6 years later.) (Preserved = 1, 5, 6, 9; photos = 1.)

• *Hylacora dilucida* Felder (det. IC & SF)—Nd.14. S.AUST., Blackwood-Belair district (NM): Captive larvae (June–Sept.) readily accepted mature lvs. of *Eucalyptus odorata*; undoubtedly on other *Eucalyptus* spp. as well. Adults (A) fly March–May (peak April–early May), coming to uv. light primarily after 2300 hrs; univoltine. See Common (1970: 857) for ♂ adult photo; McFarland (1970: 350 & 1972b: 225) for egg photos. (Preserved = 1–7, 9; photos = 2, 5.)

• *Neola semiaurata* Walk. (det. IC)—Nd.20. AUST. CAP. TERR., base of Black Mt., Canberra Botanic Gardens, nr. entrance to exhibit room (D. & NM with R. & S. Panter). Larvae (16 Jan. 72) defoliating the woody shrub, **Dodonaea multijuga* G. Don.—SAPINDACEAE (det. J. Wrigley). On this date we found 8 last instar larvae, of large size and in excellent condition, on one small shrub of *D. multijuga* which is native to the N.S.W. coast and mts., but not to the Canberra district. See Common (1966b: 103) for ♂ adult photo and line drawing of last instar. (Preserved = 5, 6, 9.)

Scythrophanes—see *Gallaba*.

• *Sorama bicolor* Walk. (det. SF, IC)—Nd.16. S.AUST., Blackwood (NM): Captive larvae (Jan. 67) readily accepted mature and semi-mature lvs. of *Eucalyptus odorata* (det. NM). Adults (B) fly Nov.–Feb. and May–Aug. (peaks Dec.–Jan. & July), coming to uv. light primarily after 2300 hrs; ♀ rare at light. Possible evidence of first instar larval dispersal was noted for this species. See Common (1966b: 105) for ♂ adult photo. (Preserved = 1–7, 9; photos = 1, 2, 5, 6.)

OECOPHORIDAE

• *Enteremna* sp. (det. IC)—W.AUST., ± 5 mi. N of Geraldton, along Beatie Rd. (D. & NM): Larvae (21 Oct. 73) in tough, conspicuous web-frass nests, on mature (old) lvs. of *Banksia attenuata* R. Br. and *B. menziesii* R. Br.—PROTEACEAE (dets. WAH). Adults emerged 23–31 May 74, at night. (Preserved = 1, 6.)

• *Myrascia megalocentra* Meyr. (det. IC)—Oc.45(M). (1) W.AUST., Moresby Range, Oakajee district, ± 16 mi. NNE of Geraldton (NM & R. G. Swinney): Larvae (late Aug. 72) abundant in well-formed, individual web-nests, on mature lvs. of *Mela-leuca uncinata* R. Br. ex Ait.—MYRTACEAE (det. NM); in a dense, undisturbed heath association, on a rocky hillside. Adults emerged early–mid Nov. 72; deposited in A.N.I.C., Canberra. (Preserved = 1, 4–7, 8h, 9.) (2) W.AUST., Moresby Range ($\pm 600'$ – $700'$ el.), Howatharra Hill Reserve, ± 21 mi. NNE of Geraldton (NM): Larvae (Aug.–Sept.) often on new lvs. of *M. uncinata* and *M. radula* Lindl.; occasionally also on new lvs. of *M. megacephala* F. Muell and *M. scabra* R. Br. (*s.l.*); all of these are relatively dense woody shrubs. See Common (1977); also Common & Bellas (1977).

• *Thudaca obliquella* Walk. (det. D. J. Carter)—Oc.44(M). S.AUST., Mt. Lofty Range, Belair Nat. Park, 1 mi. E of Belair railway station (NM & D. Bakker): Larvae (22 Sept. 69) abundant on tough mature (sclerophyll) lvs. of *Leptospermum myrsinoides* (det. NM). See Tillyard (1926: Pl. 28) for adult photos. (Preserved = 1, 4–6; photos = 6.)

PTEROPHORIDAE

• *Trichoptilus* sp. (det. IC)—W.AUST., Drummond Cove sandhills nr. beach, ± 7 mi. N of Geraldton (NM): Larvae (Nov.–Dec. 74) on (only) fl. buds, fls., and

green frs. of *Boerhavia chinensis* (L.) Aschers. & Schw.—NYCTAGINACEAE (det. WAH). The pupae took only 5–6 days to hatch! Adults emerged 7–15 Dec. 74. (Preserved = 1, 6.)

PYRALIDAE

(A) SUBFAMILY EPIPASCHINAE

• *Epipaschia (Macalla) pyrastis* (Meyr.) (det. IC, D. J. Carter)—Py.31(M). S. AUST., Blackwood (NM): Larva (Feb. 67) in tubular and extended web-nest, among lvs. of a small sapling of *Eucalyptus leucoxydon* (det. NM). A series of larvae, reared by the late J. O. Wilson (from eggs of a Blackwood ♀, April 68), readily accepted mature lvs. of *E. odorata* and reached last instar in early July. Adults (B–) fly spring–autumn. See McFarland (1970: 349 & 1972b: 223) for egg photos. (Preserved = 1, 2, 5, 6, 9; photos = 1.)

(B) SUBFAMILY PYRAUSTINAE

• **Mecyna polygonalis* Hbn. (?) (det. NM)—Py.23(M)A. (1) S.AUST., Adelaide suburbs and Blackwood (NM): Larvae (Nov.) often on **Genista maderensis*; also reported (by M. Boyce), in a garden at Burnside, on young lvs. of a South Australian native sclerophyll, *Hovea longifolia* var. *lanceolata* (Sims) Benth., and on **Podalyria* sp.—all FABACEAE (det. NM). Adults (B+) fly spring–autumn. (Preserved = 5, 6.) (2) W.AUST., ± 7 mi. N of Geraldton, at Drummond Cove (D. & NM): Larvae (Sept.–Oct.) often defoliate the coastal shrub, *Templetonia retusa* (Vent.) R. Br. ex Ait.—FABACEAE (det. NM). (3) W.AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. N of Geraldton (D. & NM): Larvae (June–July) feeding on lvs. of the small native shrub, *Bossiaea biloba* Benth.—FABACEAE (det. NM).

SATURNIIDAE

• *Antheraea helena* (White) (det. NM)—St.21. (1) S.AUST., Blackwood (NM): Captive larvae (Nov.–Dec. 66) readily accepted young lvs. of *Eucalyptus odorata* (det. NM). Adults (B) fly late Sept.–March (peaks Oct.–Nov. & Feb.); univoltine. See Common (1970: 850) for ♂ adult photo. (Preserved = 1–7, 9; photos = 3c, 4c, 5c.) (2) S.AUST., Naracoorte, nr. Lochiel Ave. (NM & TN): A newly-moulted last instar larva (27 Dec. 68) on luxuriant semi-mature (sclerophyll) lvs. of a sapling of *Eucalyptus baxteri* (Benth.) Maiden & Blakely ex Black (det. MK). (3) S.AUST., Mt. Lofty Range, Stirling, in a nursery (NM): A full-grown and healthy last instar larva (2 Feb. 67) defoliating a small, ornamental weeping birch tree, **Betula* sp.—BETULACEAE (det. NM).

SPHINGIDAE

• *Agrius convolvuli* (L.) (det. NM)—Sp.22. S.AUST., Campbelltown (Adelaide suburb): Last instar larvae (early–mid May 66) in several gardens, on the ornamental, blue-fl., annual morning glory, **Convolvulus* sp.—CONVOLVULACEAE (det. NM). Green, brownish, and black phase larvae were present. Adults (C) fly spring–summer at Blackwood; to light especially after 2300 hrs. See Common (1966b: 99) for ♀ adult photo. (Preserved = 5, 6, 9.)

Celerio—see *Hyles*.

Herse—see *Agrius*.

• *Hippotion celerio* (L.) (det. NM)—Sp.21. (1) S.AUST., Northfield (Adelaide suburb), at 19 Wright Ave. (D. Daulby): Larvae (28 March 66) defoliating the (African) arum "lily," **Zantedeschia aethiopica* (L.) Spreng.—ARACEAE (det. NM). These larvae were full size (last instar) and thriving on that plant. (Preserved = 1, 5, 6, 9.) (2) S.AUST., Blackwood (NM): Larvae (spring–autumn) on grape vines,

**Vitis* sp.—VITACEAE, which is the usual foodplant here. Adults (B-) fly late spring to mid May. (3) W.AUST., Moresby Range, Howatharra Hill Reserve, \pm 19 mi. NNE of Geraldton (D. & NM & E. C. Jaeger): Larvae (July-Sept.) on *Clematicissus angustissima* (F. Muell.) Planch.—VITACEAE (det. NM), a vine which spreads over the ground and shrubs. (4) W.AUST., \pm 7 mi. N of Geraldton, Drummond Cove (D. & NM): Larvae (Oct.-Nov.) on *Boerhavia chinensis* (L.) Aschers. & Schw.—NYCTAGINACEAE (det. P. Wilson), a perennial sp. growing on coastal sandhills. (5) W.AUST., 9 mi. S of Carnarvon, at roadside (D. & NM): Larvae (12 July 77) in abundance on the noxious weed, **Emex australis* Steinh.—POLYGONACEAE (det. NM); they were eating this in preference to many other weeds and native annuals growing here profusely, in response to rains about 6-7 weeks earlier.

• *Hippotion scrofa* (L.) (det. NM)—Sp.20. S.AUST., Goodwood (Adelaide suburb): Larvae (March 66) on **Fuchsia* sp.—ONAGRACEAE, and **Coprosma baueri* Endl.—RUBIACEAE (dets. MK). Adults (A) fly late Aug.-April (peaks Nov. & Feb.), coming to uv. light mostly after 2300 hrs (Blackwood, S. AUST.). See Common (1970: 857) for ♀ adult photo. (Preserved = 1, 5, 6, 9; photos = 5, 5c, 6c.)

• *Hyles lineata livornicoides* (Lucas) (det. NM)—Sp.23 & 23B. (1) N.TERR., 56 mi. S of Alice Springs (NM): Larvae (5 April 66) very abundant, on luxuriant spreading "mats" of an annual *Boerhavia* sp.—NYCTAGINACEAE (det. NM); most were penult. or last instar on this date. (It was obvious that this locality probably had received heavy rains during hot weather in Jan., Feb., or early March, which would account for the luxuriance of this plant and for the presence of many large larvae in early April.) See Common (1966b: 101) for ♀ adult photo. (Preserved = 5, 9.) (2) S.AUST., Blackwood (NM): Captive larvae (March 68) at first accepted the ornamental garden annual, **Mirabilis jalapa* L.—NYCTAGINACEAE (det. MK), but did not thrive. Adults (C) fly Feb.-March (coming to uv. light mostly after 2300 hrs) and appear only sporadically in the Blackwood district; they were only seen one year (1968) out of the 5 summers (1965-1969) that I lived there, but several came to light that summer, and they were also reported from other Adelaide suburbs in early 1968. (Preserved = 1-4, 9.) (3) S.AUST., Hallett Cove (S of Adelaide), along the cliff edge to the south of the cove beach (NM): Mature larvae (late March 68) were present on scattered individuals of *Boerhavia diffusa* L. (det. NM). (There had been unusual heavy summer rains in the Adelaide vicinity during hot weather in Jan.-Feb. 68).

THAUMETOPOEIDAE

• *Cynosarga ornata* Walk. (det. IC)—Ta.13. N.QLD., Atherton Tableland, around gravel quarry nr. Tinaroo Pines Caravan Park (\pm 2500' el.) (D. & NM): Larvae (March-June) of all sizes and unhatched eggs, very conspicuous on small saplings of the tree, *Casuarina littoralis* Salisb. (synonym = *C. suberosa*) (det. BH). These larvae are highly gregarious in early instars, retaining this behavior (to a very slight degree) even into last instar. Adults (March-June) were never attracted to uv., mercury vapor, or ordinary incandescent light (including the hours from midnight to dawn) during this period, nor did we ever see them flying in the daytime. However, they were regularly emerging (in captivity) all through April-June. (Preserved = 1-7, 8h, 9.)

• *Discophlebia catocalina* Felder & Rogenhf. (det. SF, IC)—Ta.3. S.AUST., Blackwood (NM): Captive larvae (Jan.-Feb.) readily accepted mature (tough) lvs. of *Eucalyptus odorata* (det. NM); strictly nocturnal feeders when past the early instars. First instar larval dispersal is notable in this species. After dispersal, they still retain semi-gregarious tendencies when small, but later become solitary. Adults (B+) fly mid Nov.-March (peak late Dec.-early Feb.), coming to lights especially on hot nights; univoltine. See McFarland (1970: 350 & 1972b: 227) for egg photos. Preserved = 1-7, 9; photos = 1, 2.)

• *Epicoma argentata* (Walk.) (det. IC)—Ta.6. N.TERR., 27 mi. E of Timber Creek store (NM): 16 half-grown gregarious larvae (18 April 66) at rest, closely side-by-

side, all on one mature lf. (of a small sapling) of an unidentified *Eucalyptus* sp. (det. NM), which was the predominant eucalypt in that locality. These larvae were transported 2,000 mi. to the south, readily accepting mature lvs. of various eucalypts enroute; they were then reared to pupation on mature lvs. of *E. odorata* (which they readily accepted) at Blackwood. (They refused to feed unless kept warm, however, as it was early winter in the south, and they had been transported from the tropics.) (Preserved = 1, 4-7, 8h, 9; photos = 5.)

● *Epicoma melanosticta* Donovan (det. IC, SF)—Ta.5; Ta.11. (1) S.AUST., Blackwood (NM): Captive larvae (April-July 66) readily accepted old (mature) sclerophyll lvs. of *Eucalyptus odorata* (det. NM) in captivity, feeding only or mostly at night when older; highly gregarious in early instars, but gradually becoming essentially solitary by last instar. I have 3 separate records of field-collected larvae of this sp. feeding on *E. odorata*, on 22 Jan. 67, 5 Feb. 67, and 27 Sept. 68; in two of the cases the larvae were small, resting or feeding in intimate aggregations of between 20 and 30 individuals; they were on very small saplings of the foodplant, not far above the ground. Adults (B) fly Nov.-mid June (peaks Dec. & late March-early May); flight nocturnal (occasionally crepuscular), both sexes coming readily to uv. light. See Common (1970: 857) for ♂ adult photo; McFarland (1970: 350 & 1972b: 225) for egg photos. (Preserved = 1-7, 9; photos = 1, 1c, 2, 5.) (2) W.AUST., Mt. Barren Range, ± 6 mi. W of Hopetoun, on top of a rocky ridge (NM & N. B. Tindale): Two last instar larvae (26 Nov. 68) feeding (0600-0700 hrs), close to the ground, on old lvs. of the shrub, *Calothamnus validus* S. Moore—MYRTACEAE (det. WAH). Although I recorded these larvae under a separate code-number (Ta.11), a ♀ adult (H. 11 Jan. 69) later proved to be *Epicoma melanosticta*. (Preserved = 1, 5, 6, 9; photos = 1, 5, 6.) (3) W.AUST., Moresby Range, Howatharra Hill Reserve, ± 19 mi. NNE of Geraldton (NM & Lisa Green): 3 aggregations of half-grown larvae (12 Aug. 78) on old lvs. of *Calothamnus homalophyllus* F. Muell.—MYRTACEAE (det. NM); in Zone 4(C) & (WC) of the reserve. (This is probably also "Ta.11.")

● *Epicoma* (sp. nov.?), nr. *tristis* Lewin (det. NM) or nr. *melanospila* (Wallengren) (det. IC)—Ta.4. S.AUST., south coast of Kangaroo Is., 10 mi. W of Vivonne Bay, on land owned by G. D. Seton, around the edges of a small freshwater lagoon (NM & M. Pate): Larvae (31 Dec. 65 and 30 Jan. 66) uncommon and scattered, on various sclerophyll dwarf shrubs of the habitat (a rather dense and richly-varied heath association), but not on eucalypts. Specifically seen feeding on *Darwinia micropetala* (FvM.) Benth.—MYRTACEAE (det. MK). Larval feeding and activity was diurnal. Adults probably fly April-May; a single most distinctive ♂ adult emerged (in a heated room indoors) on 7 May 66. I have not seen the ♀. The adults of this sp. may be both diurnal and nocturnal in activity; although I suspect the former, available evidence points in both directions! In my opinion this sp. shows a closer kinship with *Epicoma tristis* (both in the larval stage & adult) than with *E. melanospila*, although it is easily separated from either of these. See Common (1966b: 105) for ♂ & ♀ adult photos of *E. melanospila*. (Preserved = ♂ 1, 5, 6; photos = ♂ 1.)

● *Epicoma tristis* Lewin (det. IC, SF)—Ta.8 & 8A. (1) S.AUST., Belair Nat. Park, 1 mi. E of Belair railway station, just S of Sheoak Rd. (NM): Larvae (Oct.-Feb.) regularly on two completely unrelated shrubs, *Casuarina muelleriana* and *Leptospermum myrsinoides* (dets. NM). The former appears to be the "preferred" foodplant in this locality, although both are readily eaten in captivity. The larvae are gregarious when small, but become solitary and widely-scattered in later instars. They feed diurnally; sunlight and/or warmth are needed to stimulate optimum feeding activity. Adults (A), of very patchy and localized distribution, fly March-April (peak short; usually late March-early April only); strictly diurnal in activity, with ♂ flight entirely on mornings of warm days, between ± 0800-1130 hrs (peak 0815-1000 hrs) when they seek the slightly smaller ♀ ♀ resting in low bushes of the "colony" or population-center; univoltine. (Preserved = 1-7, 9-extensive; photos = 1, 2, 5, 6.) (2) S. AUST., 3.3 mi. SE of Blackwood Post Office (NM): Larvae (spring-summer) were

entirely on the abundant *Leptospermum myrsinoides* (det. NM) in this population. (For remarks on diapause in the egg stage of this sp., see McFarland, 1973: 199.)

Ochrogaster—see *Teara*.

• *Oenosandra boisduvalii* Newman (det. SF, IC)—Ta.1. (The “r” belongs in the generic name: letter from SF, 25 Aug. 1971.) S. AUST., Blackwood (NM): Captive larvae (June–Sept.) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM); strictly nocturnal feeders, hiding by day under loose bark on the eucalypt trunks and branches. First instar larval dispersal is notable in this sp., but after dispersal they still show semi-gregarious behavior (resting closely side-by-side under the bark). Capable of rapid locomotion to and from feeding and resting sites, which are often far apart. Their behavior, in this respect, is much like that of the North American arctiid, *Hemihyalea edwardsi* Pack. Adults (A) fly mid March–mid May, with ♂♂ coming to uv. light mostly after 2300 hrs; univoltine. Sexual dimorphism in this sp. (both color & maculation) is very striking; the sexes are often widely separated in collections! See McFarland (1970: 350 & 1972b: 227) for egg photos. (Preserved = 1–6, 9; photos = 1, 1c, 2.)

• *Teara ?contraria* (Walk.) (det. NM)—Ta.7 & 7A–7D. (1) S.AUST., along road to Woomera, NW of Port Augusta (NM): Larval nest-bags (3 April 66) present in countless numbers on mulga trees, *Acacia aneura* FvM. ex Benth. (det. NM); some single trees contained several dozen large (last instar) larval nests. Many of these nests were occupied by nearly fullgrown larvae (Ta.7). For numerous details on the early stages of this species and the following (Ta.9), which may be a separate species, see the interesting W.Aust. observations by Mills (1951–52). (2) S.AUST., inland desert, 64 mi. S of Coober Pedy (NM): Larvae (4 April 66) abundant, inside their large and conspicuous, ± spherical or elliptical whitish silken bag-nests, on *Cassia nemophila* var. *platypoda* R. Br. (Benth.)—CAESALPINIACEAE (det. MK). The larvae are primarily nocturnal feeders, and highly gregarious at all times for the entire duration of the larval stage. They rest by day inside the nest-bags, which are rather fully packed with dried larval frass; the frass no doubt plays an important part in temperature-regulation within the nest. Just prior to pupation (autumn to early winter) they leave the nests and wander long distances over the ground, in characteristic single-file processions, searching for pupation-sites; these “larval ropes” are often seen crossing roads in the autumn (April ±). Adults fly spring–early summer; crepuscular and nocturnal, both sexes (but mostly ♂♂) coming abundantly to uv. light; the ♀♀ sometimes fly in late afternoon, but not in great numbers; univoltine. (Preserved = 1, 2, 5, 6, 8d, 9; photos = 5c, 7c-nests.) (3) S.AUST., 44 mi. S of Coober Pedy, in a dry creek bed (NM): Larvae (4 April 66), of what I suspect are probably this same species, in silk nests on the branches, and in trunk crotches of an unidentified *Eucalyptus* sp. (det. NM). Some of the trees in this locality were nearly defoliated at the time (Ta.7B).

• *Teara* sp. (det. NM)—Ta.9. (1) S.AUST., Eyre Peninsula, ± 5 mi. N of Streaky Bay (R. Edwards): Half-grown larvae (mid Feb. 67) on the coastal *Acacia anceps* DC. (det. MK); upon capture they were crawling down the trunk in a single-file procession (sunny morning at 0730 hrs). These larvae were reared to full size (late April) at Blackwood, S. Aust. on a readily-accepted substitute, *Acacia pycnantha*. They did not make any nest-bags, but rested in a heap, all piled up together, on or in loose litter at or near the base of the foodplant, usually among their cast larval skins, on somewhat of a slight silken mat covering the litter. They were sporadic nocturnal feeders, on some nights not feeding at all. It would be interesting to know exactly what factors determine the nights of feeding. (Preserved = 1, 4–6, 9.) (2) S.AUST., at base of Black Hill, Athelstone, E of Adelaide (TN): About 30 small larvae, of ± 20–25 mm length (15 Jan. 67), sitting heaped together in a “clump,” covering part of a lf. and stem, up on a branch of *Acacia pycnantha* Benth.—MIMOSACEAE (det. TN). There was no sign of a bag (or any other silken nest-like structure) anywhere on this plant or nearby. I have not seen this particular series of larvae, but suspect they are identical to my Ta.9, based on the information provided by Mr. Newbery.

Regarding the early stages of what is probably Ta.9 in Western Australia, see Mills (1950-52). There exists some question as to whether or not this sp. (Ta.9) and the foregoing (Ta.7) are, in fact, two distinct spp.; I am inclined to agree with Mills (1951: 61, 66-67 and 1952: 87-92) that they are, but this opinion is based only upon observations of the larval stages. Aside from striking behavioral differences, the longest, silk-soft, pale gray hairs on my Ta.9 larvae were notably longer than were the longest hairs of the bag-forming Ta.7 larvae. (If both Ta.7 & Ta.9 are in fact one and the same species, as stated by some authorities, then it is an incredibly plastic species, having not only two morphologically distinct larval forms, but also two differing patterns of behavior and habits.)

Trichetra—see *Trichiocercus*.

• *Trichiocercus sparshalli* (Curtis) (det. IC, SF)—Ta.2. S.AUST., Blackwood (NM): Captive larvae (Jan.-Feb.) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM). These larvae are highly gregarious when small. This behavior gradually weakens as they grow larger, but is still retained (to some degree) into last instar. The morphology of certain structures associated with the larval mouth parts is quite peculiar and warrants close investigation. Adults (A) fly late Oct.-mid May (peaks Nov.-Jan. & March), coming to uv. light especially after 2300 hrs. Both sexes are strictly nocturnal, but the ♀ is rarely seen at lights here. The ♂ is entirely pure chalk-white, including all parts of the abdomen; in the ♀, the dense, terminal, abdominal tuft of deciduous scales is light golden-tan or golden-brown. (Preserved = 1-7, 9; photos = 1, 2, 5, 5c.)

• *Trichiocercus* sp. nov. (det. IC, SF)—Ta.10. S.AUST., Blackwood (NM): Captive larvae (July-Sept. 68) readily accepted mature lvs. of *Eucalyptus odorata* (det. NM). Larval and adult behavior is much as described for *Trichiocercus sparshalli*, but larval appearance and hair coloration in these two spp. is very strikingly different. Adults (B-) fly only from late April-early June, coming to uv. light mostly after 2300 hrs; univoltine. They are, on the average, somewhat larger than *T. sparshalli* adults, and both sexes are marked by a variable zone (not sharply defined) of sooty-blackish coloration on the abdominal dorsum. In the ♀, the dense terminal tuft is primarily black with an overlay of longer, hair-like, grayish-brown scales. (Preserved = 1-7, 9; photos = 1, 2, 4, 4c, 5, 6.)

XYLORYCTIDAE

• *Cryptophasa melanostigma* (Wallengren) (det. IC)—N.QLD., Atherton Tableland, around gravel quarry nr. Tinaroo Pines Caravan Park ($\pm 2500'$ el.) (N. B. Tindale, collector): Larvae (May-June 72) in short tunnels inside stems of *Casuarina littoralis* Salisb. (synonym = *C. suberosa*) (det. BH). Adults emerged about Sept.-Oct. (Preserved = 1, 6.)

• *Cryptophasa* sp. (det. NM)—W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Larva (Aug.-Sept. 76) in short tunnel inside a lower branch-stem of a young (2-year-old) *Acacia ligulata* A. Cunn. ex Benth. (det. NM). An adult (with cream-tan forewings) emerged in Oct. 76.

• *Lichenaula* sp. (det. IC)—Xy.41(M). W.AUST., ± 4 mi. N of Kununoppin, on top of a huge granite dome, Waddouring Hill (NM & N. B. Tindale): Larvae (1 Nov. 68) inside frass-covered silken tubes among lichens, on the granite surface, and feeding (at night and perhaps on cloudy days) on the (unidentified) LICHENS surrounding them. Several adults emerged, from the field-collected larvae, in March-April 69. (Preserved = 1, 5, 6.)

• *Genus?* sp.? (det. IC)—47(M). W.AUST., Drummond Cove, ± 7 mi. N of Geraldton (D. & NM): Larvae (March 74) in web-tunnels beneath the prickly dwarf shrub, *Acanthocarpus preissii* Lehm.—XANTHORRHOACEAE (det. WAH); on the sandhills immediately behind the beach. This record is included primarily for the unusual foodplant involved. The larval nests are conspicuous tangled webs inside the lower

parts of the plant, with a tough silken tube extending several inches down into the fine sand beneath the plant. The larvae remain in the tube (below ground) by day, coming out to feed on the tough lvs. after dark. Adults emerged June–July 74. The ♀ has oddly-narrowed, reduced wings, looking deformed. (Preserved = 1, 5, 6.)

ZYGAENIDAE

• *Hestiochora rufiventris* (Walk.) (det. SF, IC)—Zy.8 & 8A. (1) S.AUST., ± 5 mi. S of Monarto South, at Chauncey's Line (M. Fagg): Larvae (2 Oct. 66) abundant on tough mature lvs. of a single bush of *Melaleuca* sp.—MYRTACEAE (det. M. Fagg). This is presumed to be *M. lanceolata* Otto, which grew in that locality (det. NM). (Preserved = 1, 4, 5, 6, 9; photos = 1.) (2) W.AUST., south coast, on rim of escarpment ± 43 mi. W of Eucla (NM & N. B. Tindale): Adults and fresh eggs (2 Dec. 68) extremely abundant on large shrubs of *Melaleuca lanceolata* Otto (det. WAH). The adults are weak fliers and diurnal; probably univoltine. See McFarland (1970: 349 & 1972b: 219) for egg photos. (Preserved = 1, 2, 3, 9; photos = 2.)

• *Hestiochora tricolor* (Walk.) (det. SF, IC)—Zy.9. (1) S.AUST., ± 3 mi. S of Port Willunga, at the north edge of the "Aldinga Scrub," just S of Fraser St. at Bristol St. (D. & NM with the late Mr. & Mrs. J. O. Wilson): Nearly fullgrown but dormant larvae (28 July 70) resting on mature lvs. of a mallee eucalypt, *Eucalyptus fasciculosa* (det. MK), and on one other unidentified *Eucalyptus* sp. The characteristic larval "feeding-grooves," on the mature leaf surfaces, are easily recognized. (However, see also the limacodid, *Doratifera*.) Earlier in the year (14 March 70; D. & NM), freshly-emerged diurnal adults were on the wing in this same locality. Indications are that populations of this moth (a weak flier) tend to be restricted to very localized "colonies"; this remark may also apply to *H. rufiventris*. See Common (1966b: 65) or Tillyard (1926: Pl. 28) for adult photos. (Preserved = 1–7, 9; photos = 1–3.) (2) W.AUST., Kalbarri Nat. Park, ± 23 mi. E of Kalbarri township, nr. picnic area at Hawks Head Lookout, overlooking south side of Murchison River (D. & NM with K. & L. Haines): Adult ♀ sighted (mid-day, 23 Sept. 74), but I was not able to capture it. Inspection of the leathery, mature lvs. on the small mallee eucalypts here revealed old, dry scars caused by groove-like "feeding-tracks," probably made earlier in the year by larvae of this species. (This may be a W. Aust. ssp. of *H. tricolor*.)

• *Pollanisus apicalis* Walk. (det. SF, IC)—Zy.6. S.AUST., ± 8 mi. NE of Two Wells, on white sandhills (NM, TN, & M. Pate): Larvae (20, 27 Aug. 66) locally abundant on buds, fls., & young lvs. of scattered individuals of the dwarf shrub, *Hibbertia virgata* R. Br. ex DC. (det. MK). Adults (Oct.) diurnal, weak fliers; probably univoltine. (Preserved = 1, 4–6; photos = 1, 5c.)

• *Pollanisus dolens* Walk. (det. SF)—Zy.7. S.AUST., Mt. Lofty Range, nr. Longwood, at Aldgate (Heather Rd.), and in Belair Nat. Park, 1 mi. E of Belair Railway Station (NM & TN): Larvae (Aug.–Sept.) common on tough, mature lvs. of *Leptospermum myrsinoides* (det. NM). Adults (Oct.) diurnal; weak fliers; probably univoltine. (Preserved = 1, 4–7, 8d, 9; photos = 1, 5.)

• *Pollanisus viridipulverulentus* Guérin (det. NM, SF)—Zy.5. S.AUST., Blackwood-Belair district (NM): Larvae (July–Aug.) on buds, fls., and young lvs. of *Hibbertia stricta* and *H. sericea* (dets. MK); the former appears to be preferred around Blackwood. Adults (B+) fly late Sept.–Oct., occurring in localized colonies; weak fliers and diurnal; probably univoltine. See Common (1966b: 65) for ♂ & ♀ adult photos. (Preserved = 1, 5–7, 8d, 9; photos = 1.)

SUPPLEMENT: FIJI ISLANDS

AGARISTIDAE

• (?)*Sarbanissa (Seudyra) bostrychonota* Tams (det. H. S. Robinson)—As.10. VITI LEVU, nr. Nadarivatu, along trail about halfway up to the lookout on Lomalagi Peak

(NM & G. F. Gross): Two larvae (15 Feb. 68) feeding on the non-urticating lvs. of *Leucosyke corymbulosa* (Wedd.) Wedd.—URTICACEAE (det. J. W. Parham). Adults are tentatively det. as above, even though none were reared out, because Robinson (letter of 23 July 68) stated that "... this is the *only* agaristid recorded as occurring here ..." See Robinson (1975: 111 & Pl. Figs. 10–11) for ♂ and ♀ adult photos. (Preserved = 5, 9.)

ARCTIIDAE

SUBFAMILY NYCTEMERINAE

• *Nyctemera baulus* (Bdv.) (det. NM)—Ar.40. VITI LEVU, Navai-Nadarivatu district, in weedy cornfields (NM): Adults, fresh eggs, and larvae of all sizes abundant (10 Feb. 68), on the rank and weedy annual, **Crassocephalum crepidioides* (Benth.) J. Moore—ASTERACEAE (det. J. W. Parham); I also saw 2 larvae, on this same foodplant in a private garden in Suva (late Feb. 68). See Robinson (1975: 107 & Pl. Fig. 9) for ♂ adult photo. For egg photos of a close relative, *N. amica* (White), see McFarland (1970: 350 & 1972b: 229).

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COMMON NAMES OF FOODPLANTS IN THE INDEX THAT FOLLOWS:

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Aster Family—see Composites.

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¹ NOTE: In this foodplant index all species listed are South Australian except where other states are indicated by abbreviations (in parentheses after plant names) as follows: (NS) = New South Wales; (NT) = Northern Territory; (Q) = northeastern Queensland; (V) = Victoria; (W) = Western Australia. An asterisk (*) before the name designates a naturalized or introduced plant not native to the locality named in the preceding list.

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SUPPLEMENT TO VOLUME 33

ANNOTATED LIST OF LARVAL FOODPLANT RECORDS
FOR 280 SPECIES OF AUSTRALIAN MOTHS

NOEL MCFARLAND

JOURNAL

of the

LEPIDOPTERISTS' SOCIETY

Published quarterly by THE LEPIDOPTERISTS' SOCIETY

Publié par LA SOCIÉTÉ DES LÉPIDOPTÉRISTES

Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN

Publicado por LA SOCIEDAD DE LOS LEPIDOPTERISTAS



8 April 1980

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Cover illustration: Third instar larva of *Limenitis archippus* Cramer (Nymphalidae) preparing to enter winter diapause. The larva is resting on the lip of its hibernaculum constructed from the basal portion of a chewed tubular willow leaf (*Salix babylonica* Linnaeus) covered with silk. In the autumn such larvae begin facultative diapause in response to decreasing day-length. Original drawing by Mr. George C. Ford, Jr., Graphics Illustrator, Department of Biological Sciences, University of Maryland Baltimore County, 5401 Wilkens Avenue, Catonsville, Maryland 21228.

JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

Volume 33

1979

Number 4

Journal of the Lepidopterists' Society
33(4), 1979, 209-215

FIVE NEW SPECIES OF THE TRIBE EUCOSMINI (TORTRICIDAE)

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ABSTRACT. *Phaneta mayelisana*, *Phaneta verecundana*, *Eucosma atascosana*, *Eucosma guttulana* and *Eucosma diabolana* are described. Imagines, male and female genitalia, and wing venations are represented.

***Phaneta mayelisana* A. Blanchard, new species**

Figs. 1, 6, 11, 17

Head. Palpi exceeding head by about an eye diameter, white except on pale brownish gray outer side of second segment, which bears on its underside a tuft of long white scales exceeding and almost hiding downturned, white third segment. Front and vertex white. **Antennae** simple, white; pubescence in male not exceeding the scales, still shorter in female. **Thorax:** Patagia and mesonotum white, tegulae white, spotted with pale brownish gray in their middle. Abdomen whitish.

Maculation (as in Fig. 1). Fasciae white; ground color of both wings a brownish gray hue of variable saturation. Fringe of forewing white basally, peppered outwardly with brownish gray. Fringe of hindwing white.

Venation (as in Fig. 17). This insect shares with *Eucosma cataclystiana* (Walker) the unusual character that veins M_3 and Cu_1 of the forewing fuse about midway between cell and termen.

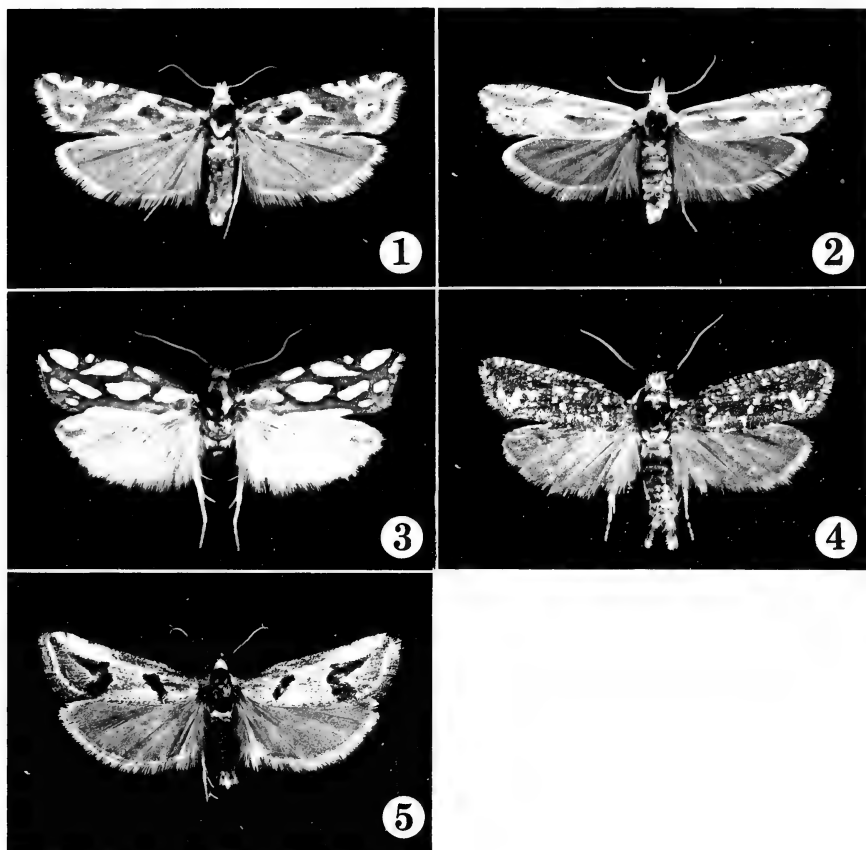
Hindwing: Rs and M_1 approximate toward base; M_3 and Cu_1 united.

Length of forewing. Males, 10.2-12.2 mm, mean = 11.1 mm; females, 11.5 mm (single specimen).

Male genitalia (Fig. 6). Figured from slide A.B. 4322, paratype from Canadian, Hemphill Co., Texas, 2.VI.70.

Female genitalia (Fig. 11). Slide A.B. 4319, paratype from Paducah, Cottle Co., Texas, 17.IV.68. The signa and the sclerotization of the ductus bursae are obscured because the genitalia took more than the optimum amount of chlorazol black. Two signa, the smaller signum more ventral. Ductus bursae with sclerotized band with a length about one and one-half times its diameter, separated from ostium by a short membranous section. Ductus seminalis attached ventrally at middle of sclerotized band. Lamella postvaginalis semicircular and well sclerotized.

Holotype. ♂, Matador Wildlife Management Area near Paducah, Cottle Co., Texas, 17.IV.68, collected by A. & M. E. Blanchard, deposited in the National Museum of Natural History (type No. 75817).



FIGS. 1-5. Holotypes: 1, *Phaneta mayelisana*; 2, *P. verecundana*; 3, *Eucosma atas-cosana*; 4, *E. guttulana*; 5, *E. diabolana*.

Paratypes. Same location, same date as the holotype, 6 ♂, 1 ♀. Gene Howe Wildlife Management Area near Canadian, Hemphill Co., Texas, 13.IV.69, ♂; 14.IV.69, ♂; 29.V.70, ♂; 2.VI.70, 2 ♂; all collected by A. & M. E. Blanchard.

Also in the National Museum are three specimens of this species: one collected by F. H. Snow in Clark Co. Kansas, June, 1962 (No. 146); one from Denver, Colorado (No. 187), no date; one from Colorado (No. 523), no date. They are included here for distribution record, but I do not make them paratypes because they are in rather poor condition.

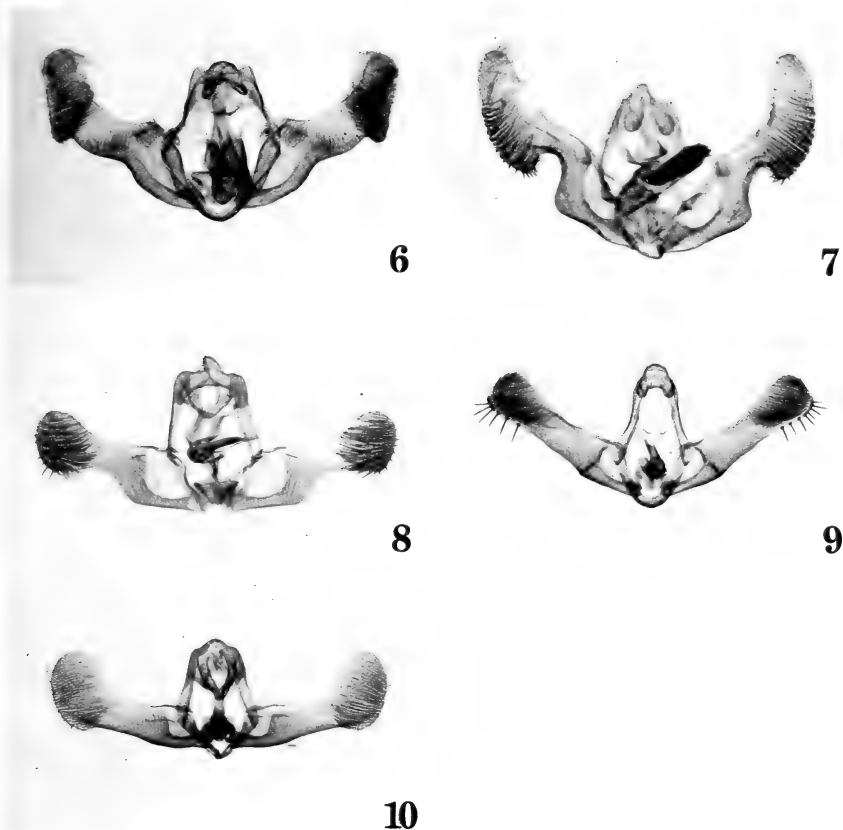
Dr. J. F. Gates Clarke who has examined some of the paratypes comments: "In pattern this is much like *columbiana*, but is a much larger insect."

I take great pleasure in naming this pretty insect for my beloved wife who collected it with me.

***Phaneta verecundana* A. Blanchard, new species**

Figs. 2, 7, 12, 18

Head. Palpi projecting the length of the head beyond front, much compressed, white with a faint grayish spot on outer side of second segment and a grayish shading



FIGS. 6-10. Male genitalia: 6, *Phaneta mayelisana*; 7, *P. verecundana*; 8, *Eucosma atascosana*; 9, *E. guttulana*; 10, *E. diabolana*.

toward end of tuft scales underneath second segment; third segment hidden by tuft. Face and vertex white. **Antennae** white, shortly pubescent in male. **Thorax:** Patagia white; tegulae white to faintly ochreous, mesonotum white. **Forewing** with arched costa, termen oblique, concave between veins R_s and Cu_1 .

Maculation (as in Fig. 2). Forewing white with markings pale ochreous in males but generally somewhat darker in females. Hindwing whitish to pale gray.

Venation (Fig. 18). Veins R_s and M_1 of hindwing very closely approximate toward base; veins M_3 and Cu_1 united.

Length of forewing. Males 7-9 mm, mean = 8 mm; females 7.3-8 mm, mean = 7.6 mm.

Male genitalia (Fig. 7). Slide A.B. 4340, paratype from Canadian, Texas, 13.VIII.71.

Female genitalia (Fig. 12). Slide A.B. 4341, paratype from Canadian, Texas, 28.V.70. Corpus bursae membranous, two signa present; ductus bursae with some sclerotization around it near ostium.

Holotype. ♂, Gene Howe Wildlife Management Area near Canadian, Hemphill Co., Texas, 15.VIII.71, collected by A. & M. E. Blanchard, deposited in the National Museum of Natural History (No. 75818).



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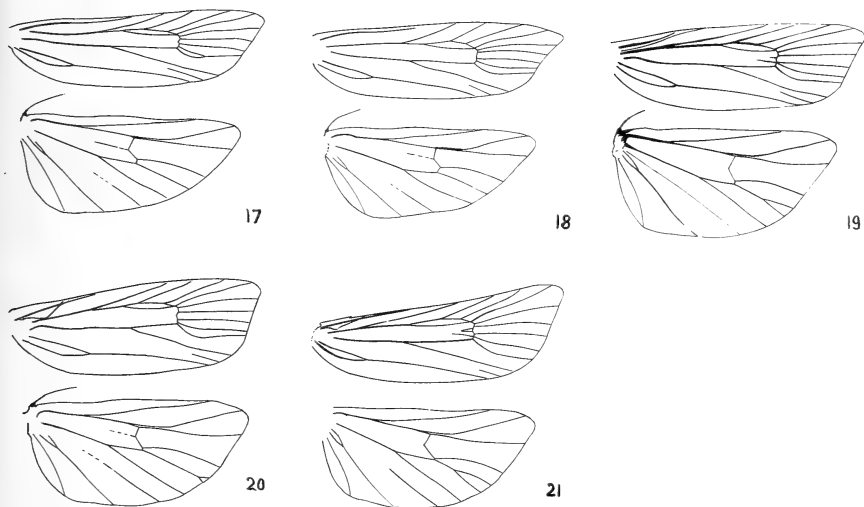
FIGS. 11-16. Female genitalia: 11, *Phaneta mayelisana*; 12, *P. verecundana*; 13, *Eucosma atascosana*; 14, *E. guttulana*; 15, *E. diabolana*; 16, *E. graziella*.

Paratypes. Same location as holotype, 28.V.70, ♂, 4 ♀; 13.VIII.71, 4 ♂. Matador Wildlife Management Area, near Paducah, Cottle Co., Texas 4.VI.70, ♂; all collected by A. & M. E. Blanchard. Dr. J. F. Gates Clarke who examined two of my dissected paratypes commented as follows: "Very similar to *indagatricana*, but in (*verecundana*) the costal strigulae of the forewing are confined to the outer half of the costa, in *indagatricana* they go nearly to the base of the costa. The genitalia also differ: in the male the neck of the harpe (valve) is much narrower and the excavation of the ventral edge of the harpe is much deeper in (*verecundana*) than in *indagatricana*; also in the female of (*verecundana*) the postvaginalis is not sclerotized but is in *indagatricana*."

***Eucosma atascosana* A. Blanchard, new species**

Figs. 3, 8, 13, 19

Head light ochreous; palpi exceeding front by an eye diameter; tuft on underside of second segment externally ochreous, slightly compressed, loosely scaled, concealing



FIGS. 17–21. Venations: 17, *Phaneta mayelisana*; 18, *P. verecundana*; 19, *Eucosma atascosana*; 20, *E. guttulana*; 21, *E. diabolana*.

third segment. **Antennae** slightly compressed laterally, finely ciliate in male, light ochreous. **Thorax:** Tegulae and anteromedial mesonotum ochreous brown; posterior tuft white. **Abdomen:** whitish ochreous.

Maculation (as in Fig. 3). Forewing: rich yellowish brown, a little paler in the fold, with silvery white spots showing negligible variation in all specimens before me. All white spots, except the elongate one along the dorsum and the one near the costal fold, surrounded by line of dark brown scales; fringe pale ochreous with a darker line near base; male costal fold extending to about one fourth of the costa. Hindwing: pale ochreous with concolorous fringe.

Length of forewing. Males 11.5–13.0, average 12.5 mm; females 11.0–14.0, average 12.0 mm.

Venation (Fig. 19).

Male genitalia (Fig. 8). Slide A.B. 4489, paratype from Laguna Atascosa, Cameron Co., Texas, 22.XI.73.

Female genitalia (Fig. 13). Slide A.B. 4459, paratype from Laguna Atascosa, Cameron Co., Texas, 22.X.73. Corpus bursae and ductus bursae membranous; two large signa; lamella postvaginalis about one and one half times as long as broad, lightly sclerotized, with long setae.

Holotype. ♂, Laguna Atascosa National Wildlife Refuge, Cameron Co., Texas, 22.XI.73, genitalia on slide A.B. 4313, deposited in the National Museum of Natural History (No. 75821); collected by A. & M. E. Blanchard.

Paratypes. Welder Wildlife Refuge near Sinton, San Patricio Co., Texas, 28.X.64, ♂; 12.XI.65, ♂; 13.XI.65, ♀. Voshell Wildlife Management Area, near Brownsville, Cameron Co., Texas, 12.XI.68, ♂; 5.XI.69, 6 ♀; 9.XI.69, ♀; 26.X.70, ♂. Laguna Atascosa Wildlife Refuge, Cameron Co., Texas, 19.XI.73, ♂; 22.XI.73, 4 ♂, 7 ♀; collected by A. & M. E. Blanchard.

This insect is close to *Eucosma sandiego* Kearfott, as shown by their male genitalia and maculation. Dr. J. F. Gates Clarke who compared some of my specimens to the *sandiego* specimens in the National Museum commented: "Generally the spots of your species are larger and more rounded than in *sandiego* and the three subterminal spots of your species are larger and more distinct than those in *sandiego*. The neck of the harpe of your species is narrower than that of *sandiego*."

***Eucosma guttulana* A. Blanchard, new species**

Figs. 4, 9, 14, 20

Head. Palpi exceeding front by half eye diameter; second segment white medially, whitish above; external side and shaggy brush of long scales on underside tawny; third segment smoothly scaled, downturned, tawny. Front and vertex white, spotted with tawny. **Antennae** simple, tawny; pubescence in male barely exceeding the scales. **Thorax:** mesonotum tawny with white anterior band and white posterior tuft. Tegulae tawny with white tip. **Abdomen** pale ochreous above, paler beneath.

Maculation (as in Fig. 4). Forewing: ground color varying from ochreous to tawny or even dark brown; spots white, except the three larger faintly ochreous ones forming an ill-defined ocelloid patch. Fringe white, basally speckled with ground color. Hindwing: slightly paler than ground color of forewing; fringe whitish, basally darker.

Venation (Fig. 20). Hindwing veins R_s and M_1 approximate toward base; veins M_2 and Cu_1 fused almost to termen.

Length of forewing. Males 7.5–12.0, mean = 9.5 mm; females 9.0–11.0, mean = 10.3 mm.

Male genitalia (Fig. 9). Slide A.B. 3597, paratype from Padre Island, Nueces Co., Texas, 9.IX.74.

Female genitalia (Fig. 14). Slide A.B. 4460, paratype from South Padre Island, Cameron Co., Texas, 30.III.78. Papillae anales large, with a blunt ventral process turning caudodorsally. Lamella antevaginalis heavily sclerotized; lamella postvaginalis broader, crescent shaped, weakly sclerotized; ductus bursae slightly sclerotized between junction with ductus seminalis and ostium, but not immediately cephalad of ostium. Corpus bursae with a wide slightly sclerotized medial band that includes ventral and dorsal signa.

Holotype. ♂, Padre Island National Seashore, Kleberg Co., Texas, 19.VII.76, collected by A. & M. E. Blanchard, deposited in the National Museum of Natural History (No. 75819).

Paratypes. All from Texas: Engeling Wildlife Management Area near Tennessee Colony, Anderson Co., 30.IV.66, 2 ♂; 6.IX.66, ♂. Camp Strake near Conroe, Montgomery Co., 27.IV.67, ♂; 22.IV.69, ♂. Matador Wildlife Management Area, near Paducah, Cottle Co., 8.VIII.68, 6 ♂, 3 ♀. Gene Howe Wildlife Management Area, near Canadian, Hemphill Co., 28.V.70, ♂. Welder Wildlife Refuge, near Sinton, San Patricio Co., 30.VI.75, ♂, ♀. North Padre Island, Nueces Co., 9.IX.74, 5 ♂, ♀; 19.IX.74, 2 ♀; 12.III.75, ♂; 30.IX.75, 2 ♂, ♀; 17.VIII.76, 2 ♂; 19.VI.77, 4 ♂; 21.VI.77, ♂; 6.IV.78, 5 ♂, 2 ♀. Padre Island National Seashore, Kleberg Co., 2.X.75, ♂, ♀; 17.V.76, 2 ♂, 2 ♀; 19.V.76, ♀; 19.VII.76, ♂. South Padre Island, Cameron Co., 1.III.78, ♂; 30.III.78, 21 ♂, 3 ♀. Attwater Prairie Chicken National Wildlife Refuge near Eagle Lake, Colorado Co., 27.IV.78, 2 ♂; collected by A. & M. E. Blanchard.

Remarks. This species is closely related to *Eucosma robinsonana* Grote as shown by the genitalia of both sexes and the wing venation, but the maculation is very different and it is a much bigger insect.

I have this insect only from eastern and southern Texas and from the Panhandle of Texas: none from the wide intervening territory. The specimens from the Panhandle are generally lighter in color (ochreous instead of tawny or brown) than those from the East and South, but this appears to be no more than a color variation.

***Eucosma diabolana* A. Blanchard, new species**

Figs. 5, 10, 15, 21

Head. Palpi exceeding front by half an eye diameter; second segment white anteriorly and medially, outer side pale brownish; underside with tuft of very long, dark brownish scales greatly exceeding the smoothly scaled, downturned, half hidden third segment. Front and vertex whitish. **Antennae** fasciculate in male, shortly pubescent in female. **Thorax:** mesonotum and tegulae ochreous.

Maculation (as in Fig. 5). Forewing: from where the background is palest, near

apex, to the dark fasciae, the color is of about the same hue, varying only in saturation; that is from a very pale ochreous near apex to a rich brown with an orange tinge in the two large fasciae and near base along costa. Most wing scales and all the fringe scales are white tipped. Hindwing: Concolorous with the parts of the forewing with average saturation only a little grayer.

Venation (Fig. 21). Hindwing: R_s and M_1 approximate toward base, M_2 connate with stalk of M_3 and Cu_1 .

Length of forewing. Males 10.3–18.0, mean = 13.6 mm; females (three specimens): 12.0, 12.7, 13.4 mm.

Male genitalia (Fig. 10). Slide A.B. 1233, paratype from Mt. Locke, Davis Mts., 26.III.68.

Female genitalia (Fig. 15). Slide A.B. 4443, paratype from Sierra Diablo, 20.V.68. Lamella antevaginalis a narrow sclerotized lip; lamella postvaginalis subquadrangular with setae; ductus bursae membranous with narrow constriction near ostium. Corpus bursae membranous with two minute signa.

Holotype. ♂, Sierra Diablo Wildlife Management Area, 6,000 ft, Culberson Co., Texas, 31.III.70, collected by A. & M. E. Blanchard, deposited in the National Museum of Natural History (No. 75820).

Paratypes. Davis Mts., Mt. Locke, 6,500 ft, Jeff Davis Co., Texas, 26.III.68, ♂; Sierra Diablo Wildlife Management Area, 6,000 ft, Culberson Co., Texas, 20.V.68, 5 ♂, ♀; 29.III.70, ♂; 31.III.70, 6 ♂, ♀; 3.IV.70, ♂; 27.V.73, 8 ♂, ♀; 29.V.73, 2 ♂; 30.V.73, 2 ♂, collected by A. & M. E. Blanchard.

Remarks. "The smaller specimens (of *E. diabolana*) remind one of *mirosignata* Heinrich, but your species is distinct and presumably undescribed" (Dr. J. F. Gates Clarke, in litt.). The genitalia, male as well as female, are also very different.

Eucosma graziella A. Blanchard

Fig. 16

Remarks. This species was previously described (Blanchard, 1968) but the female genitalia had not been studied. Fig. 16 is drawn from slide A.B. 4446, the genitalia of a female taken in the Chihuahuan Desert, near Nugent Mt. at Big Bend National Park, Texas, 3.X.67. The ventral and lateral parts of the sterigma loosely surround the small ostial chamber; its dorsal part extends caudad as a subquadrate lamella postvaginalis. There is some slight sclerotization of the corpus bursae mediodorsally near the dorsal signum.

ACKNOWLEDGMENT

I am deeply grateful to Dr. J. F. Gates Clarke for examining critically much of my material and comparing it with the material in the National Museum. Without his unstinted help this article would not have been possible. I also want to thank Mr. Fletcher of the BM(NH) for helping me in the same manner.

LITERATURE CITED

BLANCHARD, A., 1968. New moths from Texas (Noctuidae, Tortricidae). J. Lepid. Soc. 22: 143.

HOW TO MAKE REGIONAL LISTS OF BUTTERFLIES: SOME THOUGHTS¹

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ABSTRACT. Procedures are described for making two types of regional lists of butterflies: the state or provincial list, and the "local study" (an intensive, long-term investigation of a small area). The need for such lists, problems in making them, and some of the expectable results, are examined. A logarithmic scale for describing population sizes is given, as is a procedure for estimating total number of species in a local area.

STATE AND PROVINCIAL LISTS

State or provincial lists are important sources of regional information about a variety of aspects of butterflies, the particular aspects being up to the writer. At the least such lists should include distribution records, and they may also provide data on number and timing of broods, habitat choice, rarity, phenotypic and geographic variation, and so on.

As I pointed out many years ago (Clench, 1949), these lists are invaluable to taxonomists, zoogeographers, ecologists, and to researchers concerned with many other types of problems as well. They are also useful to both resident and visiting collectors, showing when and where to look for particular species. An often little-appreciated value of such lists is in their "negative information" content: an omission can inform the collector of needed data—a still unknown food-plant, an unguessed fall brood, as well as the more striking unrecorded species—and thereby encourage him to publish any such newly acquired information.

Methods

It is useful, in gathering and storing data, to keep two loose-leaf notebooks: a species book and a county book.

The species book is the main list and comprises a separate sheet for each species, more eventually if needed. On each species sheet enter the full data for all records of that species that you acquire. Enter the records as received, in no particular order. I always put the

¹ At the Lepidopterists' Society meeting in Louisville in 1978 I gave a paper on this subject, and several of those attending suggested that the information be made more permanently available. I here comply with that suggestion, amplifying and extending the original paper in a few places.

This paper considers two kinds of regional lists: state lists or their equivalent; and what I call "local studies"—long-term investigations of small areas. Each requires a different approach, and each will be treated separately.

² Editor's note: This paper is published posthumously following Mr. Clench's sudden and untimely death in April 1979. A future issue of the *Journal* will be published as a memorial to commemorate his many contributions to the study of Lepidoptera, and to the Lepidopterists' Society.

county name to the left in a column of its own, with the remaining data in full to the right. The county column thus may be scanned rapidly for particular records. Data entered on this sheet should comprise full locality data (including, when appropriate, elevation and mountain range), date, source, as well as any other information associated with the record. Do not omit the source. One of Murphy's Laws is that the record whose source you neglected to note will later become critical.

It is also helpful to add a distribution map for each species. Such a map, even if you only tick off the counties recorded (instead of spotting all records exactly), will give you a good general picture of the range of the species in your state, and the areas from which more information is needed.

The county book contains a sheet for each county, parish, or equivalent subdivision. Simply enter the names of all species recorded from that county (referring to the species book for the full data). An easy way to simplify the procedure is to type up a one page list of all species known or strongly suspected to occur *in the whole state*. With elite type, single spaced, and using three columns, you can get 150 species or more on one side of an 8½ × 11" sheet. Add a blank line at top right. Reproduce this sheet—by quantity-photocopying or mimeograph—to the number of counties in your state (get some additional copies: they are always useful). For each county, take one of these sheets and write the county name on the blank line. Then simply check off the species you have recorded from that county. On the reverse you can note sources of particular importance for that county: published accounts, resident collectors, etc.

In the far west, where counties are particularly large, it may be advisable to subdivide them into more useful smaller units for data recording, in whatever arbitrary way is most appropriate to your needs, and most easily and accurately described to others. The subdivision preferably should be by linear, objective boundaries, such as a river. Be careful using highways, however: they can be rerouted or renumbered and cause confusion in later years.

Recording your data in these two books allows you to keep records with a minimum of time, and a maximum of utility. You have instant access to what you know about either a particular species, or a particular area.

Sources of Preliminary Data

Earlier lists of one kind or another are already published for many states or provinces, or for parts of them. Such lists have often appeared in obscure journals of limited distribution, and learning about them

can be a problem. An outstandingly useful source is Field, dos Passos, and Masters, 1974. This bibliography, as its authors note, is not necessarily complete, so you should do some extra searching. In addition to earlier regional lists, monographs of various genera and other taxa often contain many locality records.

Collections. (a) Large museums have at least some material from almost every state and province. (b) Small museums, state colleges and universities, state museums, nature centers, etc., often have local and/or student collections. These may prove to be a gold mine of early or otherwise unusual records, but watch for poor data. (c) Private collections and collectors are probably your richest source of information outside your own efforts. The local collector has often been active for many years and may have exceptionally complete data on the species in his area: identities, broods, timing, larval foodplants, and so on, information of the utmost value and not duplicated elsewhere. I have found such collectors to be extremely helpful and invariably more than willing to share their hard-won knowledge.

Problems. (a) Misidentifications. With experience you soon learn which are the problem children: among them *Erynnis*, *Hesperia*, and other hesperiids; *Euphydryas*, *Speyeria*, some lycaenids, *Calephelis*. You may want to borrow specimens to confirm an identification, or send your own to a specialist. In any event, do not hesitate to query or even omit a dubious record, or you can assign it to the "hypothetical list" (see below). "*Thorybes* sp." is much preferable to "*Thorybes bathyllus*" which is actually *Thorybes pylades*. The famous early Cuban naturalist, Felipe Poey, has a wise saying: *Más vale ignorancia que error* (Ignorance is worth more than error).

(b) Stick to what you know. Do not assume any species—even *Pieris rapae*—to be anywhere. Even common species may have gaps in their ranges, and this would be important and interesting information. If you find what seems to be a gap in the range of a species that "shouldn't" have such a gap, go check it out. It may be real.

Procedure in Fieldwork

Ideally your fieldwork should be conducted in two concurrent phases: (1) an intensive, prolonged study of a small, easily accessible area (see under "local studies" below); and (2) field trips to farther places within your state or province.

The principal goal of the latter is to add as many distributional data as possible, expressed (or summarized) in terms of county records. Your aim is to acquire as much information as you can in the time at your disposal. Initial efforts should be directed at simply adding as many county records as possible. Pick the season when the most

species are flying (often June and July, but not always or everywhere), and visit as many counties as time and funds permit. A fairly respectable list of species and county records eventually will be amassed, and your attention may then gradually shift to intensified efforts at more specific goals: a county still poorly represented; a species that ought to be present but of which you have few records or none. The search for such a species is more efficient if you first familiarize yourself with available information about its habits, larval food, flight periods, and so on. Remember, some species fly only in particular seasons, especially the spring, so seasonal collecting should be added to your field exploration program.

Although you can think of the task as one of accumulating county records, always remember that that is not the *real* goal but merely a simplified accounting procedure, useful for record-keeping and statistical treatment. With that in mind, it may help to discuss some possible patterns you may observe.

Every county has some upper limit to the number of species in it. In a reasonably diversified state some counties will have relatively many species, others fewer. If the counties are more or less uniform in size and range of habitats, then the number of species in them should be distributed in a Gaussian or normal curve, as in Fig. 1B.

Before you have begun to accumulate records, all counties in the state have precisely zero species known from them: they would all be ranged in a single bar at the extreme left of such a curve. As you acquire records the counties begin to move up the graph to the right. A single visit to a hitherto uncollected county may result in a dozen or so species records, shifting that county up one class interval to the right. With more visits the number will gradually increase. In Pennsylvania, a state I know well, a reasonably well-worked county—several visits in different seasons—will have records of some 20–60 species. To increase the number beyond that point takes far more effort, generally possible only by residence or intensive local collecting.

After some years of work, both on your part and on the part of earlier workers as well as collaborators in various parts of the state, the distribution of counties according to number of species will look something like Fig. 1A, which shows the current state of knowledge of Pennsylvania butterflies. Note that the curve at this time is essentially three-humped: (a) a group of 25 counties (37% of the 67 counties in the state) with fewer than 20 records each, representing those either collected in briefly or not at all; (b) a group of 28 counties (42%) with between 20 and 60 records each, representing those visited a number of times and in different seasons; and (c) a group of 12 counties (18%)

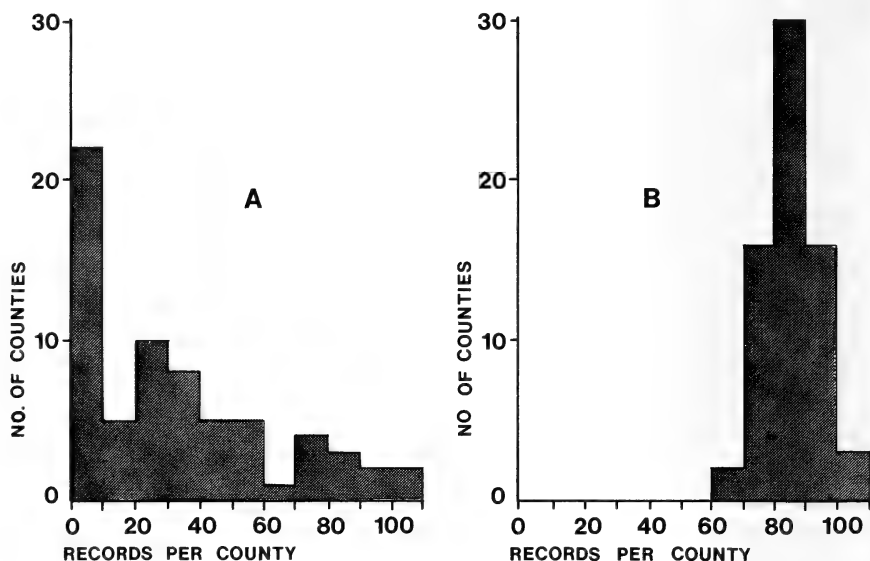


FIG. 1. **A.** Present state of knowledge of Pennsylvania butterflies. Note the three humps in the curve: a group of counties with fewer than 20 records each; a group with between 20 and 60 records each; and a group with 60 or more records each. **B.** If all Pennsylvania counties were completely known, the curve would probably look essentially like this.

with 60 or more recorded species each. These last are counties with a long history of collecting (Allegheny and Philadelphia counties); or with collectors long resident (Lancaster Co. [George Ehle], or Tioga Co. [George Patterson]); or in which especially intensive, long-term collecting has been done (Westmoreland Co., where Carnegie Museum has a field research station). The distribution of collecting intensity in Pennsylvania as measured by the number of species known from each county, is shown in Fig. 2.

If the curve in Fig. 1B is summed (midpoint of each class interval times number of counties in the class interval, and these totalled), we have a theoretical maximum possible number of county records for Pennsylvania of about 5,715. The total number now actually known is 2,215, or 39% of those possible. Although this seems like a small number, it is the result of many thousands of hours spent in the field by collectors over more than a century. It shows dramatically how difficult it is to get truly thorough knowledge about even one state. I should add, however, that because several areas have been intensively studied, about 145 species are now known from Pennsylvania,

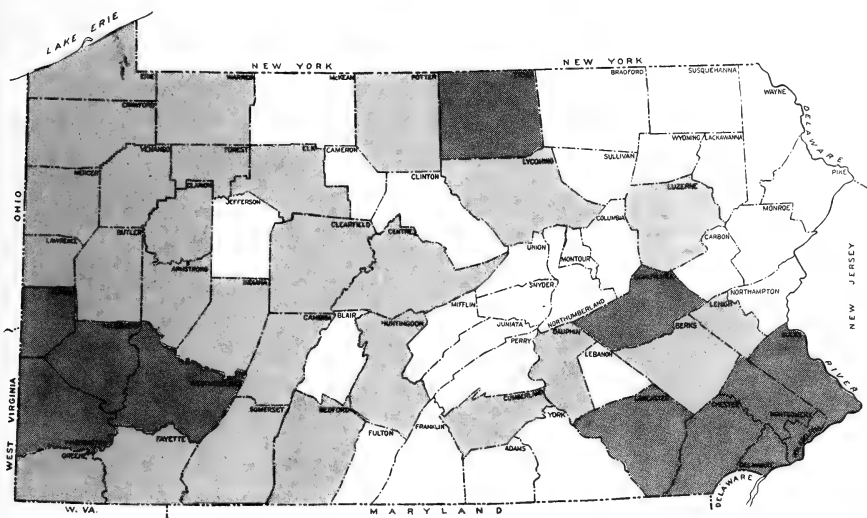


FIG. 2. Distribution of collecting intensity by counties in Pennsylvania. Counties with no shading have 20 or fewer records each; those with light shading have between 20-60 records each; and those with dark shading 60 records or more each.

and this total is not likely to be much increased in the future: perhaps by no more than about 10.

Special Matters

Wherever you may be, you can help other lepidopterists. Perhaps a taxonomist revising a group needs material or information from your state; or a geneticist may want to find a colony of a particular species in your area, or someone working on Monarch migration might need local dates of immigration or emigration. For all such people the special knowledge you have acquired could be of great value. And do not forget reciprocity: his (or her) special knowledge may be of particular value to you someday as well.

Be aware of research that already has been done and that is relevant to your area, and make an effort to extend the results. One frequent problem is the nature of the boundary between two wide-ranging subspecies. If that boundary passes through your state, and the material you have acquired is adequate, you are uniquely situated to add precision to what is known.

You may discover new problems. No general rule applies here. Keep an inquiring mind, and be alert for things that "don't fit." Perhaps you know of a local population with a different flight period than

the species has elsewhere, or with a higher-than-usual frequency of some dimorphic form. Or you might have noticed a persistent and anomalous absence of some species from areas where it should be found. A new species turning up in your area might represent a range expansion, something we know little about.

The Goal

The objective in preparing a state list is the accurate record of conditions in a particular place—your state—at a particular time or times, and in as much detail as you are capable of.

Accuracy is vital. Rumored occurrences and sight records are admissible *only* if they are clearly so reported. Misidentifications, ideally, should never occur. Some few are bound to, but make every effort to eliminate them completely: submit doubtful specimens to a specialist; record any uncertain identifications as such. Be meticulous with specimen data, and ultracareful in recording the information.

Data on brood numbers and timing, on larval foodplants, and other attributes, should be clearly identified as to geographic source. If you have no local data it is proper and even wise to copy from the literature (because it will provide clues for future users of your list), but you should clearly indicate that the information was not locally obtained.

Be aware of old records not recently duplicated; of species common now but not mentioned by “the old boys.” Such things may seem unimportant but could fit in with data from other areas to demonstrate a pattern. A recent instance of this began with the account of *Nathalis iole* by Kimball (1965). He remarked on the absence of early records from the state and concluded that it might have established itself in Florida relatively recently. I became interested, checked two large museum collections and other early literature and concluded that *iole* indeed previously was absent from Florida, that it reached the state in 1913 or shortly before, and spread north from its probable original landfall in the Keys (Clench, 1976).

Miscellaneous

A state list may invite a zoogeographic or ecological analysis, or other derivative study. If your interests lie in these directions, so much the better: a list can only be improved by such work. But these “extras” are not *necessary*. What *is* necessary is a careful, accurate compilation of reliable information. If you provide this, then your list will be a valued and respected contribution to our science, useful and used for a long time to come.

The “*hypothetical list*.” Ornithologists are familiar with this term; lepidopterists are not. In your published list itself, include only species with established reliable records. Save the rest for the “*hypothetical list*” at the end. It is the perfect place for the doubtful species, the “possibles,” those previously reported in error. Anything dubious can go in. This device allows you to avoid the difficult decision of what to include in, and what to exclude from, the main list. Amplify and discuss the entries as you will. The “*hypothetical list*” is a wonderful place for the reader to browse when your paper is eventually published.

The work of assembling a state list is never done. Information always remains to be learned, and always will. The trick is knowing when you have reached the point when you can properly say, “This is now worth publishing.” Eventually the time comes when you have a reasonable picture of the butterflies of your state, embodying a satisfying quantity of new data. If at this point the influx of new information slows, then the time clearly has come to put it all together and get it into print.

As the foregoing should have intimated, preparing a state list is not a simple task. It requires experience, knowledge, and judgement, as well as diligence. It is not really a job for a beginner. If you are a beginner, however, and you really want to undertake such a task, then you should seek as much advice and help as you can from those with more experience. If you do that, then there is no reason not to produce an excellent and valuable piece of work.

LOCAL STUDIES

A *local study*, as I use the term here, is an intensive, long-term investigation of a small area: perhaps one or two thousand acres, about as much as can be covered reasonably well on foot in a single day.

Studies of this kind have been undertaken so seldom that wherever you choose to do so you will be rewarded with significant data, well worth publishing. Because it requires no extensive collections and no large reference library this kind of study is particularly suited to the serious lepidopterist in a rural area. Bear in mind that much of the information you acquire, even though it seems of little interest in itself, will gain greatly in value when added to similar information from elsewhere. Among the most important eventual results of such work will be establishing geographic patterns of variation in brood numbers and timing, larval foodplant choice, abundance levels, and other things about which we are still totally, or almost totally, ignorant.

Define or enunciate what you want to do at the outset, and give it careful thought. One important aspect of a local study is time variation, for which you need data extending over as long a time as possible. The earlier you start keeping records, the longer your time-span of useful information.

Do not make your goals too many or too complicated or you will defeat your own purposes. Know about how much time you will have for the work and plan accordingly. After your first month or two, review your program and your goals. Perhaps you have bitten off more than you can chew; or perhaps you could easily do more than you first thought.

The place: what to look for. Frequent visits are important. The nearer your chosen spot is to your home, the more often you can visit it.

The study area you choose should be reasonably representative of your region; with enough habitat diversity this should be so. In a pinch, however, almost any area will do: even a vacant lot in town, if you cannot get to anything better. Nevertheless, in a day's survey you can record useful data on a large number of species, so (within reason) the more diverse the area the better.

Your study area should have—and have had—no pesticide spraying. It should be free from any abrupt, major change in land use: you do not want the place bulldozed for a shopping center a year after you begin! And it should be as free of people as possible. When you are hard at work in your area you need to concentrate, to be free to follow this or that butterfly, to observe what it does. People, even the best intentioned, interfere with this work.

If you are lucky, a weather station (government or private) may be located in or near your study area, and you can arrange for copies of the data. Failing this, then look for a weather station as near as possible, and in as similar a habitat as possible, and record what you can in your own area on your own visits. This is not as satisfactory, but some idea of the regional climate is necessary.

State or local parks, perhaps even a national park, if they fit other requirements of your study, may include suitable sites. If permits are required, you must get them. In any event you should get permission. The personnel of the park may even be able to help you locate the best place for your study, if you explain your needs and aims.

Universities and other institutions often have their own study areas, designed for investigations of just this kind. If so, they are ideal: they are stable in land use, free of insecticides, often have climatic records, and frequently have background data on vegetation, land use history, maps of habitat types, and so on. They may also have a policy of

limiting the area to their own personnel. Sometimes, however, they are only too happy to let you use the area, if you ask first, explain your aims, and don't mistreat the area.

Private lands often have ideal places for such a project. Again, ask the owner and get his permission first. In recent years the land owner has gotten much more hard-nosed about strangers on his land. He or his neighbors may have been victimized by careless or malicious campers, wanton vandals, drunken or stupid hunters, and who knows what else: his attitudes can hardly be faulted. In most cases, however, if you can satisfy him that you are serious, and that you will not trample his crops or leave trash behind you, he will willingly let you use his property.

In using any land ordinary courtesy is necessary. Do not litter; do not walk on crop plants; do not leave gates open if they were closed, and vice versa, follow paths as much as possible. If the area is already in use by other researchers, familiarize yourself with what they are doing and be careful not to interfere with their projects. Respect fully any ground rules that may be in force. Regardless of who owns the land, it is good public relations to keep them informed, if only in a general way, of your progress. If you find a rarity, or make an important or unusual discovery, tell them. Land owners or managers like to hear that their place is "special." And when you publish, acknowledge them by name, and give them a reprint of your paper.

Methods

I assume that you have chosen an area, and that you will be making periodic visits, perhaps once a week or so. As in state lists, I keep two books of records:

(1) Log book. This need not be loose-leaf, as it is strictly chronological: on each visit enter date, time you begin fieldwork, and time you finish. Record weather data (temperature, cloud cover, wind; and any important changes during your visit). List the species you take or observe in the area, where you see them, how common they are, their condition: these three matters are discussed more fully below. Record any special observations, such as territorial behavior (time of day, territorial activity, size of territories, and so on), predator attacks (details), mating or courtship behavior (nature of activity, time, sex of the flying partner in copulating pairs, and so on), unusual numbers, oviposition records, flowers serving as adult food, etc.

(2) Species book. This should be loose-leaf, to allow additions. A separate sheet (or more) for each species, entering dates, particular places, and other information from your log. It will be repetitive, certainly, but this accumulation of data is the core of your whole project.

You will need to accumulate a voucher collection, either keeping it yourself, or giving it to some institution. It should comprise reasonable series of each species, and of each brood, and of any problem groups or unusual specimen for which documentation or later study may be necessary. After this, collect as little as possible: the job is primarily one of observation and recording. With a little familiarity, most species can be identified without capture. Certain groups, such as *Polygonia*, *Erynnis*, or some of the smaller hesperiids, may need to be captured for reliable identification. Many can then be released, but some must be kept for more careful identification later. Be alert for the rare species that in the field looks much like some common species.

The following procedures can improve the accuracy and detail of your observations, and hence their later utility. Your study area can be divided into a number of "microlocalities." It is important to be able to specify these, in order to localize observations on habitat choice, colony locations, and so on. Two basic methods are used:

(1) A grid system, in which the whole area is marked off by a rectangular grid. In one type of grid the squares are identified, "B-6," for example, referring to the square in row B, column 6. In the other type of grid the lines are identified, so that a square may be specified by the intersection of some standard corner, or a point identified by a fractional designation such as "5.6 E, 6.1 N," meaning 0.6 unit east of line 5 and 0.1 unit north of line 6. A grid system can be particularly precise, but it requires more than just drawing the lines on a map: you must have some means of identifying them on the ground, too, or they are of little use. Survey markers along trails or at grid line intersections is one method. Generally, if the area you use does not already have a grid system, it is too involved and expensive to set one up.

(2) Place names. Sometimes an area under study will have them, or some of them already. If so, use them. If they do not exist, then you will need to make them up. Do so with thought. It is tempting to use such terms as "Idalia Meadow" or "Hypaurotis Scrub," but such names may sometimes cause confusion in your notes. The same may be true of botanical adjectives. Other kinds of names can be more practical, sometimes even silly ones. One of our places at Powdermill is called "Elephant Walk." I'm not sure why, but it is certainly easy to remember. "*Typha-Acoris* Marsh" is there, too, and poses no problem, for that combination of plants occurs at Powdermill in only one place. However you do it, keep a record on a map of the locations, and document them with photographs.

Recording the condition of the specimens you see is extremely use-

ful, particularly when visits to the area are at weekly or greater intervals, because they give a valuable clue to how long the species has been flying. I use a series of five lower case letters: *a*, perfect and unblemished; *b*, showing slight wear; *c*, definitely worn; *d*, extremely worn; and *e*, a complete rag, the wings so rubbed that identification may be difficult. The important thing in this scale is wing wear, and it increases with age, so record tears in the wings separately. A tear (or bird or lizard bite) can happen in a fresh specimen and means little in this connection. Remember, you are using the scale to estimate the relative age of the individual since eclosion, *not* to describe an exchange item! When you see a number of individuals of a species on a particular day your notes might read, "all *a*" (suggesting quite recent emergence), or "*b-d*, most *c*" (suggesting about the midpoint of the flight period or a little later), or "most *d*, one *a*" (suggesting a second flight beginning as an earlier flight is ending), and so on.

Words like "common" or "scarce" convey a poor idea of numbers; mark-recapture techniques can give accurate population figures, but the procedure is far too time-consuming for routine use. Some years ago I devised a compromise system, more accurate and objective than words, less tedious than population estimation; it is easily used, as subsequent experience with it has shown. This abundance measure is a logarithmic scale much like that of stellar magnitudes used in astronomy, after which it was patterned. The scale records numbers seen per hour, or the equivalent, as follows:

Scale	Numbers
0	125-625 individuals seen per hour
1	25-125 " " "
2	5- 25 " " "
3	1- 5 " " "
4	0.2- 1 per hour, or 1 seen per 1-5 hours
5	1 per 5-25 hours
6	1 per 25-125 hours
7	1 per 125-625 hours
8	1 per 625-3,125 hours

The scale can be extended in either direction if needed (it rarely will be): -1 would be the next commoner scale unit, and so on. Each abundance unit represents $\frac{1}{2}$ the abundance of the preceding unit, and a difference of one unit is about the minimum that can be accurately perceived in routine observation.

In recording abundance take due note of highly localized species (count only time spent in suitable habitats) and of flight periods (count only time spent in appropriate months).

If you know your average rate of movement through an area, and the average width of your "sweep"—the distance you can effectively survey on either side of your path (which will vary with the terrain as well as your vision and knowledge of local butterflies)—then the measure can be converted into a rough density measure of so many per acre, or hectare, or whatever.

When only a single specimen is seen, its abundance should be entered as "4 or rarer," "5 or rarer," etc., because catching one individual cannot establish a time span.

The measure is crude, but about as accurate as possible in the circumstances. Remember, too, that any measure based on visual sighting will generally underestimate true numbers.

Persistence pays. The whole idea is to continue observations for a long time—several to many years—in all seasons. The following kinds of data should be expected and sought:

Species list. The list will never be complete—something often not realized—but with enough time you can approach completeness about as closely as you wish. If you record the total accumulated number of species you have found (S), and the total accumulated time (in hours) you have spent observing (N), then the following relation (Clench, 1968) will describe your results quite closely:

$$S = Se \frac{N}{K + N}.$$

Se is the theoretical total number of species in your area, and K is an adjustable constant, related to "collectability."

Powdermill Nature Reserve (of Carnegie Museum of Natural History) is an area of about 2,000 acres, located 9 miles south of Ligonier, Westmoreland Co., Pennsylvania. Since its establishment in 1956 I have worked on its butterflies as time allowed (little in recent years, but intensively in the 1960's). A total of 820 hours has been logged, and 73 species recorded in that time: $K = 59$, and $Se = 78$ species. In short, we have found about 94% of the species expected there, with only 5 left to go (see Fig. 3).

Calculating the "best fit" values of Se and K is difficult and complicated, too much so for inclusion here. You can approximate them fairly simply, however: draw a smooth, eye-fitted curve through your graphed data points; pick two well spaced positions on this curve (or

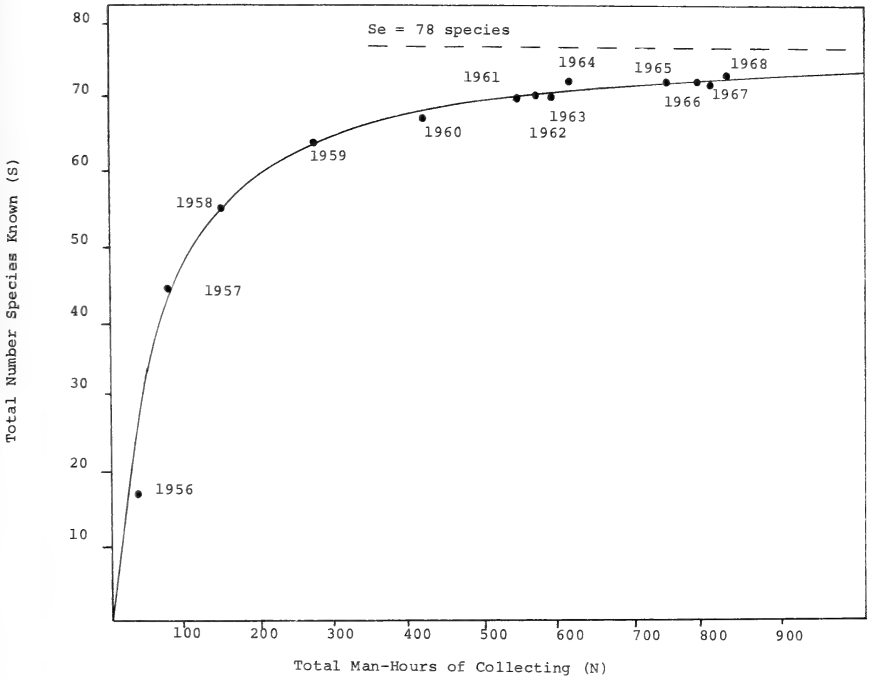


FIG. 3. Collection curve of butterflies for Powdermill Nature Reserve (Westmoreland Co., Pennsylvania). Spots represent cumulative man-hours of collecting (*N*) and species recorded (*S*) at the close of each indicated year. The curve follows the formula:

$$S = 78 \left(\frac{N}{59 + N} \right)$$

two well spaced data points which touch it), substitute their *S* and *N* values in the formula, and solve the two simultaneous equations for *Se* and *K*. If your eye-fitted curve was well drawn, the results should be fairly accurate.

A word of caution: the formula has ramifications and complications that I have not mentioned and it should be used judiciously. By way of example, *Se* actually represents the size of the “universe” being sampled, and this may vary: a one-day universe is smaller than a one-year universe, and that in turn is smaller than a two- or a ten-year universe. A spring universe may be smaller than a midsummer universe and so on.

How many flight periods are there, and when? In any species the timing, if not the number, of the flights varies from year to year, pre-

sumably because of variation in weather conditions. It takes several years of observation to establish reliable average times.

One of the reasons for a diversity of flight periods among the species of a community is to minimize competition for adult food—normally flower nectar—and a thoughtful examination of your data in this light could produce interesting results.

Population levels. Each species has an average level of abundance: some are rare, others commoner, and some are abundant. In any given area the frequency distribution of species according to abundance is close to log-normal, that is, the frequency distribution approximates a normal curve when abundance is plotted on a logarithmic scale. Since the abundance scale ("0-8") described above is logarithmic, a frequency distribution of the species based on their average abundance according to that scale should approximate a normal curve. The curve is truncated at the rare end, but the degree of truncation diminishes with prolonged study. Most species vary considerably in their numbers from year to year, and again it takes a number of years of observation to establish reliable average values. Some species may have different abundance levels in different broods, and this variation, too, should be looked for.

Cycles of commonness and rarity are often present, but beware of generalizing too much from them. Many cycles are transient, or not truly cycles (having varying periods).

True regular cycles are uncommon. Eventually you should find in some species a "boom and bust" phenomenon. This is a season (or flight) of exceptionally high numbers, followed by a crash, during which you will see only a few individuals, or even none at all. A return to normal numbers soon follows. At Powdermill I have seen this in a few species (*Euphydryas phaeton*, *Polygonia comma*, *Epargyreus clarus*, *Hesperia leonardus*) over about 16 years of observation. In each of these only one eruption was seen, ordinarily about 2 abundance units above normal, followed by a crash of similar magnitude, with a return to normal numbers the year after.

Habitat choices. With appropriate observation and recording, the principal habitat and subordinate habitats of most of the species should be learned in comparatively few years. Watch for species that regularly occupy two or more different habitats, especially (a) for feeding, and (b) for courtship, reproduction, larval growth, and inactive ("sleeping") adult occupancy.

Territorialism. Many butterfly species are territorial. The subject has scarcely been touched, and much remains to be learned. Persistent observation should reveal territorial individuals if you are alert to what the butterflies are doing. Absence of territorialism in a species

is harder to document, for individuals of territorial species are non-territorial part of the time. Some species occupy territories only at certain times of the day (such as *Vanessa atalanta*, in late afternoon). In most territorial species males occupy the territories, and females wander in search of them.

Life history data such as larval foodplants and adult food sources should be noted. If you rear the early stages you can learn much more.

Long observation of an area will often show some transient species that move into an area, live for one or a few seasons, and then die out. At Powdermill, *Nastra therminieri* arrived, lasted for several years, then disappeared, and has not been seen since. Both *Euptoieta claudia* and *Hylephila phyleus* established colonies that died out after a single brood.

The Monarch, *Danaus plexippus*, is a special transient since it regularly moves into an area in the spring, raises a local brood or two, then emigrates in the fall. The fall southward migration is conspicuous and often spectacular. It is important to keep records of its size, direction, and dates of start and finish. Just as important, however, is the time of Monarch arrival in the spring, a far less documented event because it is so inconspicuous. One can only note the date of first spring sighting.

Inevitably, long-term observation will produce genuine resident rarities, such as the celebrated *Erora laeta*, or strays from outside the area—single individuals of non-resident species.

When you have studied an area intensively for several or many years you are apt to find significant, non-random changes. They may be changes in the trend levels of certain populations, but they could be other things as well. As succession alters a meadow, grassland species may change from common to rare, or perhaps even disappear; a species not seen before may move in and establish itself, perhaps only temporarily, perhaps permanently.

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DAILY FLIGHT PERIODS OF MALE CALLOSAMIA PROMETHEA (SATURNIIDAE)¹

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ABSTRACT. Flight periods of male *Callosamia promethea* were determined by marking their positions in a large flight cage at hourly intervals from 0800 to 2000, and recording the number in flight and the number moving from previous positions. Nocturnal flight activity was determined by marking male positions ca. 1 h after sunset and again at sunrise. Flight activity occurs from 7 h before to 1 h after sunset and peaks 5-2 h before sunset. Preliminary observations of female pheromone release indicate that pheromone release is synchronous with male flight activity, and peaks 4-1 h before sunset. Pheromonal stimulation may be an important component in initiation of male flight activity.

It has long been known that males of *Callosamia promethea* (Drury) are attracted to females by a pheromone during the afternoon, usually between 1400 and sunset (e.g. Ferguson, 1972; Collins & Weast, 1961; Eliot & Soule, 1902; Mayer, 1900). Rau & Rau (1929) attempted to quantify the flight period of *promethea* by releasing both bred and wild caught numbered males at various distances from caged females and noting the time of arrival of males. They found a peak of activity from 1600-1640 Central Standard Time at St. Louis, Missouri, with 14 of 33 recaptured males returning during this period. They also observed one male arriving at dawn with males of *Hyalophora cecropia* (L.), though they did not state to which species (female *cecropia* or female *promethea*) the *promethea* male was attracted. In all of the above work, male flight periods were apparently determined by watching caged females and observing time of male arrivals. Thus, these observations do not establish conclusively that flight activity of male *promethea* is limited to the afternoon. This aspect of behavior can be determined only by watching males throughout the day.

Because of our studies on mimicry, involving the release and recapture of variously painted *promethea* males (Waldbauer & Sternburg, 1973; Sternburg et al., 1977), it became necessary to define more precisely the flight activity of males. If male *promethea* were nocturnal as well as diurnal, nocturnal predators could account for the differential recapture of mimetic vs. non-mimetic color patterns observed by Sternburg et al. (1977). The non-mimetic yellow pattern

¹ Part of the Ph.D. dissertation presented by the first author to the Department of Entomology, University of Illinois.

may be more conspicuous at night than the black mimetic pattern. If males fly only in the afternoon, then exposure to diurnal predators will be less than if males were to fly in both the morning and afternoon.

MATERIALS AND METHODS

We used freshly emerged male and female *promethea* reared on wild black cherry (*Prunus serotina* Ehrh.) or tuliptree (*Liriodendron tulipifera* L.) at Urbana, Illinois. Adults emerged from pupae allowed to overwinter in an outdoor insectary. These stocks originated from wild populations from the vicinity of Charleston, Illinois or Medaryville, Indiana.

Males were individually distinguished by white numbers painted on the ventral surface of the hindwings. They were released into a flight cage (2.36 m \times 1.83 m \times 2.36 m) containing a wild black cherry tree (ca. 1.8 m tall) and a recording thermograph. They were observed, their positions marked, and the number in flight (if any) noted at hourly intervals from 0800 to 2000 (all times Central Daylight time) each day from 8 to 11 July 1977. There were 16 males in the cage on 8, 10, 11 July, and 15 males on 9 July. New males were added to the cage at 1100 on 10 and 11 July. They were allowed to settle; then their positions were marked. At the next hourly observation, their positions were noted along with the positions of males which had been present all day. Only one of the 15 males added to the cage this way moved during that hour. This four-day intensive observation period was supplemented by less regular observations from 3 June to 8 July that are not included in the table.

Night activity in 1977 was determined by mapping the positions of males at sunset and again at sunrise. When it was found that no movement took place between sunrise and 0900, the morning observations were changed to between 0700 and 0900. These observations were made on eight nights in June, 1977, using a total of 115 males. Because a higher percentage of these males moved at some time during the night than expected (22.8%), nighttime observations were repeated in 1978.

The flight cage was moved to a new location over a small, dense, low-growing barberry (*Berberis*) cultivar in an effort to provide males with sheltered resting sites. However, most males continued to rest on the sides and top of the cage (see below) rather than in vegetation. Male positions were marked between 2100 and 2200 and again between 0500 and 0600 the following day. Sixty-two observations on 30 males were made between 29–31 May and between 5–7 June 1978.

RESULTS AND DISCUSSION

Table 1 shows that most diurnal flight activity of male *promethea* occurs during the afternoon between 1300 and 2000. The peak of activity occurs from 1600 to 1700, 4 to 3 h before sunset. There is some activity in the morning, but we believe this may be an artifact of confinement in the flight cage. The natural resting site of wild males is presumed to be in vegetation, but they often rested on the sides or top of our cage. For example, on the morning of 8 July, 13 of 16 males were resting on the sides or top of the cage and not in the tree. Seven of these 13 males moved during the period 1000–1100 (70% of all males moving during these hours on all four days). Of those moths moving, three moved 0.3 m or less. Of the four remaining males, three moved from exposed positions on the top of the cage to sheltered positions on the cage sides, while the fourth male moved from an exposed position on one side to a sheltered position on another side. We believe that males which moved in the morning were shifting from positions exposed to the sun, possibly to avoid increasing temperatures. On 8 July, when most of these males moved, the temperature reached 31.1°C at 1400, the highest recorded for the four-day period, and was already 29.4°C at 1100. During the period 1000–1100, 8 July, the temperature rose 2.8°C, the largest increase in temperature in one hour during the period 0800–1100 on any of the four days. The maximum temperature for the other three days during the period 0800–1100 was 27.2°C, while the largest hourly increase in temperature was 2.2°C. Other morning movements were similar in that males moved from exposed to sheltered positions, although not all males in exposed positions moved. None of the males which rested in the tree (five males over four days) moved before 1400. Only three males were observed to fly in the morning, one because it had been disturbed (Table 1). Males were observed in flight primarily at 1600 and 1700, corresponding well with the number of males observed to change their positions.

In 1977, 23 of the 115 males observed to determine nocturnal movements were eliminated from the data: 11 because they could not be found at sunset to mark their positions, one because it flew to an unknown location when it was disturbed as its position was marked, and 11 because they died during the night. Of the remaining 92 males, 21 (22.8%) moved during the night. This is a higher percentage of movement than expected. The 1978 observations indicate that this high percentage was the result of marking male positions too early in the evening. In 1977, male positions were marked at sunset, which occurs shortly after 2000 in Urbana at the time of year these obser-

TABLE 1. Diurnal movements of male *Callosamia promethea* (Drury) in a flight cage by time of day on 4 days. The table includes 63 observations per hour on 31 different males.

	Hour of observation													
	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	
Number of males changing position (n)	0	0	0	10	5	3	15	18	47	59	45	31	12	
% of males changing position (n/63 × 100)	0	0	0	15.9	7.9	4.8	23.8	28.6	74.6	93.6	71.4	49.2	19.0	
Number of males in flight (n)	0	1	0	2	0	2	7	7	30	15	8	3	1	
% of males in flight (n/63 × 100)	0	1.6	0	3.2	0	3.2	11.1	11.1	47.6	23.8	12.7	4.8	1.6	

uations were made. Table 1 shows that nearly 20% of males moved between 1900 and 2000. In 1978, male positions were marked between 2100 and 2200, approximately one hour after sunset. When this was done, only two males (3.2%) were observed to move during the night. Both of these males exhibited wing fluttering behavior when their night positions were first marked, and did not fold their wings and rest quietly during the 20 to 30 minute period required to mark all male positions. Thus it seems likely that these two males moved shortly after we left the flight cage for the night.

Preliminary observations of virgin female *promethea* indicate that peak flight activity of males corresponds roughly to peak pheromone release by females. Sixty-eight females were watched in the early afternoons of 16, 29, 30 June and 1, 5, and 6 July for extrusion of an abdominal gland, which, on the basis of male behavior, is obviously the source of the sex pheromone. Females began extruding this gland between 1400 and 1500 (three females) and by 1700, 59 of the 68 females had extruded it. Of the remaining nine females, eight extended the gland during the next hour; while one had not extruded her gland by 1800 when observations ceased. Observations of some of these and of other females during the morning and early afternoon (before 1400) indicated that the abdominal gland is never extended between 0800 and 1300. Thirty-three females were watched on the evenings of 14, 15, 16 and 22 June to observe times of retraction of the abdominal gland. One female retracted the gland between 1800 and 1900, 12 retracted it between 1900 and 2000, and 20 retracted it between 2000 and 2100. At this time of year sunset occurs at Urbana between 2023 and 2026. Thus, female *promethea* stop releasing pheromone before twilight ends. To make sure nocturnal release did not occur, 12 females were watched all night on 22 June. Observations were made hourly up to 2200, and every 2 hours thereafter until 0600, 23 June. Females were observed with a flashlight covered by a red cloth to minimize disturbance. At no time did any of them extrude their abdominal glands.

Collins & Weast (1961) noted that certain atmospheric conditions could cause males to fly as early as 1300. Their times are presumably standard times, while ours are daylight times; thus our 1400 corresponds to their 1300. We noted that females tended to extrude their glands earlier on cloudy days, but did not make enough observations under appropriate conditions to quantify this.

Skinner (1914) found that male *Callosamia angulifera* (Walker) were attracted to female *C. promethea* between 2000 and 2100. In the course of our release-recapture experiments with painted male *promethea* in Urbana, we attracted a male *C. angulifera* with a female

promethea sometime between 1930 8 August and 1900 9 August, 1977, and another male *angulifera* sometime between 1300 12 June and 1900 13 June, 1978. Ferguson (1972) notes that female *C. angulifera* attract males between dusk and midnight, with a peak activity at 2200. The slight overlap of *promethea* pheromone release and *angulifera* flight activity may account for this interspecific attraction. The three species of *Callosamia* appear to be reproductively isolated by their differing pheromone release and male flight periods (Ferguson 1972) but the ability to attract males of one species with females of another indicates that this isolating mechanism occasionally breaks down.

Brown (1972) suggested that males of *Callosamia securifera* (Maassen) did not need a pheromone stimulus to start flight activity, which occurs from 1000 until 1500 in this species. Our observations indicate that pheromonal stimulation may be a component of flight initiation in *promethea*. For example, on 9 June at 1425, 10 males were in the flight cage in the same positions they had occupied since 0940 that morning. Two females were in a cage upwind close by and neither had been observed to extrude the abdominal glands all day. Between 1425 and 1435 most of the males began quivering, a characteristic behavior exhibited immediately before afternoon flights, and four males actually flew. We then checked the female cage and found that one female was extruding her abdominal gland. The second female extruded her gland 10 min. later. By 1500, all but 2 of the males had flown. By moving female cages downwind, we could often cause males in the flight cage to settle. No experiments were tried where females were absent to see if males would fly without pheromonal stimulation, as the area in which the flight cage was located possesses a wild population of *promethea* and the possibility of stimulation by a wild female could not be excluded.

Other work by Jeffords, Sternburg and Waldbauer (in prep.) indicates that male *promethea* do fly in the afternoon without pheromonal stimulation. They released painted males of *promethea* at Allerton Park, Piatt Co., Illinois, where either no or a very small wild population of *promethea* exists, and then recaptured these males one day later in traps baited with virgin females. Wing damage analysis and the ratio of mimetic to non-mimetic painted male recaptures indicated that these males had flown the previous day when no females were present. However, the possibility of stimulation by wild females cannot be entirely discounted.

CONCLUSIONS

Male *promethea* are diurnal fliers, with a peak activity between

1500 and 1800, or between 5 and 2 h before sunset. The slight amount of morning movement is believed to be an artifact of confinement in a flight cage. Nocturnal movement does occur, but it is limited to a period less than 2 h after sunset and is thus more appropriately considered crepuscular. Thus males are exposed in flight to predators mainly in the afternoon.

Female sex pheromone release is apparently confined to the afternoon between 1400 and 2100 and peaks between 1600 and 1900 (4 to 1 h before sunset). No nocturnal or morning release, as evidenced by extrusion of the abdominal gland, was noted. Male flight activity may be initiated by reception of the female pheromone, and/or it may be the result of endogenous rhythms or other environmental stimuli.

ACKNOWLEDGMENTS

We thank Dr. C. T. Maier for the use of the flight cage, and Dr. W. H. Luckmann and the Illinois Natural History Survey for the use of the experimental area and facilities for rearing *promethea*. This work was supported by NSF Grant DEB 76-18618 to Waldbauer and Sternburg.

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COMPOSITES AS HOST PLANTS AND CRYPTS FOR *SYNCHLORA AERATA* (GEOMETRIDAE)

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ABSTRACT. Thirteen genera of Asteraceae have been recorded as host plants of the geometer moth *Synchlora aerata*. These flower-feeding larvae not only live on their food plants but also use the host plants as sources of raw material to disguise themselves. The larvae cut off flower parts, entire flowers, and even entire inflorescences and attach them to spiculiferous processes on their dorsal surface. If this floral covering is removed the larvae immediately replace the camouflage; furthermore, the larvae maintain the effectiveness of the covering by replacing withered floral parts with fresh ones. Adaptation to the use of host plant material as camouflage enables the larvae to exploit, with greater safety from predators a greater range of potential food plants.

Little is known of the life history of the larvae of geometer moths. On the basis of their structure and behavior in relation to concealment from predators, the larvae so far described can be divided into three distinct groups: 1) those that are slender and twig-like; 2) those with moderate dorsolateral processes bearing specialized hooks for the attachment of plant fragments as an aid to concealment, and 3) those with large dorsolateral processes not specialized for the attachment of plant matter (Ferguson, 1969). Of interest here are the behavioral characteristics and host plant relations of *Synchlora aerata* with the Asteraceae (=Compositae). *Synchlora aerata* belongs to the second of the above groups.

Larvae of *S. aerata* were observed on, and collected from, two species of *Liatis* on the coastal plain of North Carolina in Carteret Co., and on three species of *Solidago* on the piedmont of North Carolina in Orange Co. They have also been reported on seven other composite genera (Table 1). Larvae of *S. liquoraria liquoraria* and *S. frondaria* have also been reported on composites (Table 1).

METHODS AND MATERIALS

The larvae were collected and transplanted to terraria where their feeding behavior, and their use of plant fragments as camouflage, could be observed. The response of the larvae was studied under the following conditions: 1) when camouflage was removed by artificial means, and 2) when host plants were changed. In the latter case,

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TABLE 1. Summary of the species of *Synchlora* and their known composite host plants.

Species	Host plants	Citation
<i>S. aerata</i> (Fabricius)	<i>Ambrosia</i> sp.	Ferguson (1969)
Dyar	<i>Coreopsis</i> sp.	Ferguson (1969)
	<i>Erigeron canadensis</i>	Ferguson (1969)
	<i>Rudbeckia hirta</i>	Ferguson (1969)
	<i>Rudbeckia</i> sp.	Ferguson (1969)
	<i>Ageratum</i> sp.	Anonymous (1890)
	<i>Eupatorium</i> sp.	Anonymous (1890)
	<i>Liatris graminifolia</i>	Treiber*
	<i>L. spicata</i> var. <i>resinosa</i>	Treiber*
	<i>Solidago canadensis</i>	Treiber*
	<i>S. nemoralis</i>	Treiber*
	<i>S. pinetorum</i>	Treiber*
	<i>Aster</i> sp.	Dyar (1960)
<i>S. liquoraria liquoraria</i>	<i>Artemisia californica</i>	Comstock & Dammers (1937)
Guenee	<i>Solidago</i> sp.	Comstock & Dammers (1937)
<i>S. frondaria</i> Guenee	<i>Bidens</i> sp.	Ferguson (1969)
	<i>Pluchea odorata</i>	Ferguson (1969)
	<i>Chrysanthemum</i> sp.	Kimball (1965)

* First report.

larvae feeding on *Liatris* were transplanted to *Solidago* and vice versa. One individual was successfully reared and was the basis for identification as *Synchlora aerata*. Voucher specimens of both the larval stage and adult stage have been deposited into the U.S. National Museum, Dept. of Entomology, Smithsonian Institution.

FEEDING AND LOADING BEHAVIOR

Observations on feeding and camouflage-loading behavior were first made on *Liatris spicata* var. *resinosa* (Fig. 1). In each case, the larvae began dissecting individual flowers by cutting the corolla tube vertically between lobes for a distance of 1–2 mm, then cutting perpendicularly to the long axis of the corolla tube for nearly its entire circumference. The corolla was further dissected into fragments with 1 to 3 lobes. The cut edge of each section was passed through the larva's mouth, and carefully attached to a spiculiferous process on its back (Fig. 2). As the fragments were passed through the mouth of the larva, a mucilaginous substance was secreted by the larva onto the fragments, this substance seems to play a role in maintaining turgor in these fragments. Next, the style (and in a few cases pappus hairs) were bitten off and also treated as described above. The larva then

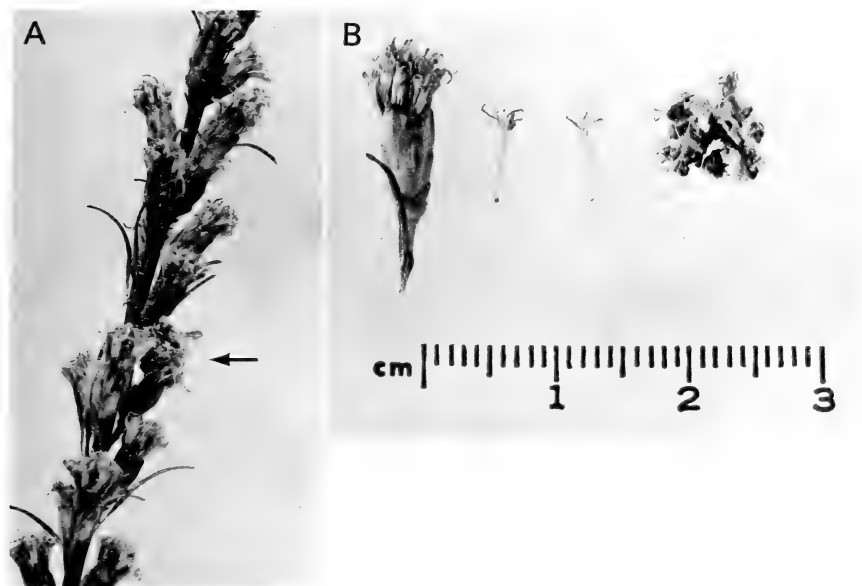
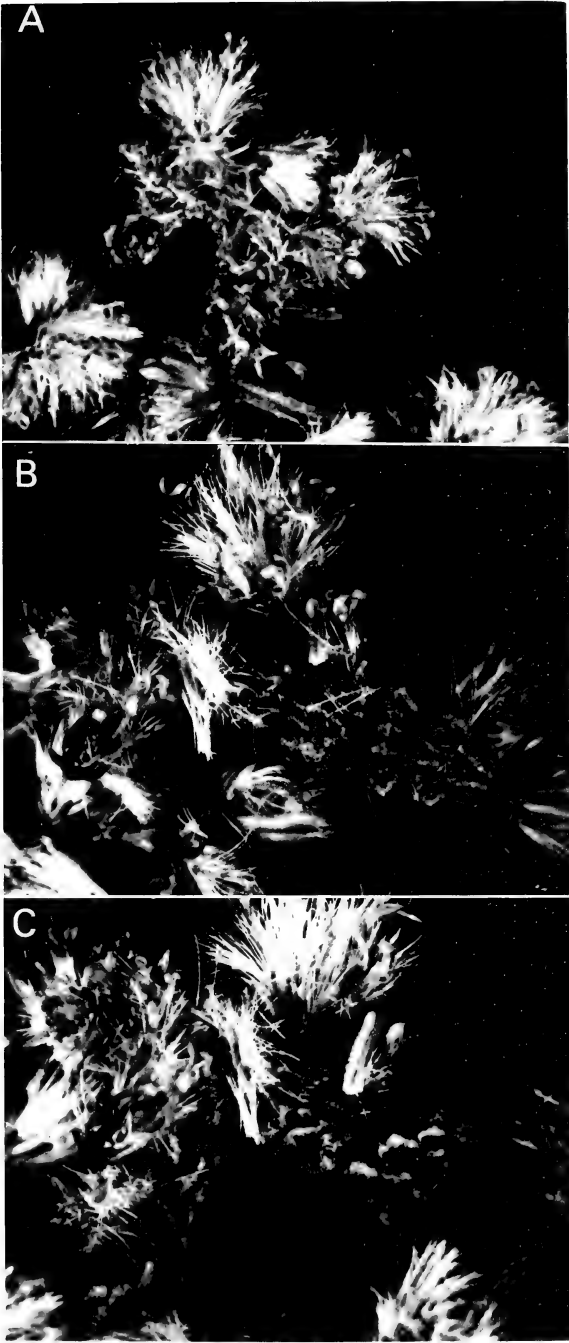


FIG. 1. Macrophotographs of the larva of *Synchlora aerata* on *Liatris spicata* var. *resinosa*; (A) inflorescence stalk of *L. spicata* var. *resinosa* with arrow pointing to the location of a fully camouflaged larva and (B) a comparison of the size of an inflorescence and of a flower of *L. spicata* var. *resinosa* with a fully camouflaged larva.

devoured the anther sacs and pollen, which apparently provide its chief source of nourishment, although some corolla and styler tissue was also observed being ingested. In no case was the ovary of the flower damaged.

Even when the disguise is complete, maintenance is required. Two kinds of maintenance are recognized: 1) the addition of a mucilaginous substance, which appears to maintain turgor in the plant fragments, and 2) the replacement of "older" missing, lost, or wilted tissue with "new" tissue. Apparently, the "old" tissue is either ingested by the larvae or discarded at some point and subsequently replaced. Thus the loading process is more or less continuous.

The feeding behavior on *Solidago* flowers was similar to the behavior observed when feeding on *Liatris*, that is, the principal nourishment was derived from the anthers and pollen, as well as from occasional feeding on styler and corolla tissue. However, the camouflage-loading behavior was different. On *Solidago* the floral dissecting process described above was omitted. Instead of dissecting corolla fragments, the larva bit off entire inflorescences and attached them to its back in the manner described for *Liatris* (Fig. 2). Apparently, frag-



ments from the larger flowers of *Liatris* were sufficient to provide a camouflage; however, in the small-flowered *Solidago* species, flower fragments were insufficient to effect a viable camouflage. Both types of loading behavior, described above, were exhibited by the same larva.

In order to better understand the loading behavior and the relationship between feeding and loading, three larvae were artificially denuded. The larvae immediately began to feed and load alternatively until their camouflage was complete. In similar experiments on *Chrysopa slossonae* (Neuroptera) Eisner et al. (1978) found that the relative priority the larvae give to these two activities is variable and is dependent on the degree of satiation. However, in the case where the larvae were denuded and hungry, the larvae divided their time between loading and eating. In addition, denuded larvae, as well as larvae with a complete disguise, were transplanted from *Liatris* to *Solidago* and vice versa. The denuded larvae again began to feed and load until the disguise was complete. The larvae, with a complete camouflage of plant material from the first host plant, were observed to replace these plant fragments with floral material from the second host plant. Replacement proceeded in the same manner as observed in the maintenance process. Whether or not the difference in host plant was recognized by the larvae can only be conjectured; however, the result was a complete change of the larvae's covering to match the new host plant.

DISCUSSION

The adaptation of loading plant fragments, flowers, and/or inflorescences as a disguise by the larvae of *Synchlora aerata* effects an apparently successful camouflage against winged predators. More importantly, this adaptation enables the larvae to feed on a variety of related host plant species rather than being restricted to a specific host plant, as in the case with adaptations to special marking or coloration, due to predator pressure. This adaptation is viewed as an important evolutionary adaptation enabling the larvae of *S. aerata* to exploit a greater range of potential food plants. This conclusion is supported by the relatively large number of composite genera that have been recorded as host plants.

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FIG. 2. Macrophotographs of the larva of the geometer moth *Synchlora aerata* on the goldenrod *Solidago canadensis*; (A) showing the orientation and arrangement of goldenrod inflorescences attached to the dorsal surface of a larva; (B) dorsal view of larva after removal of a portion of its camouflage, and (C) lateral view of larva after removal of a portion of its camouflage.

ACKNOWLEDGMENTS

I thank Drs. C. R. Bell, Guy L. Nesom, and J. N. Rinker for their critical review of this manuscript and Drs. John C. Downey, Herbert Neunzig, and Thomas Eisner for their enlightening discussions and encouragement. Linda S. Treiber and Mary L. May have my appreciation for their field assistance; and I thank Paul Marx for his photographic advice and assistance.

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Journal of the Lepidopterists' Society
33(4), 1979, 244

A NEW METHOD OF INDUCING COPULATION IN *PHYCIODES THAROS* (NYMPHALIDAE)

While engaged in breeding experiments using various populations of *Phyciodes tharos* Drury, I happened on a method of inducing copulation that may be widely applicable to other butterfly species. It proved extremely difficult to achieve matings by the hand-pairing technique or in small cages using several population cultures of *P. tharos* in my laboratory. The difficulty appeared to be both an unusually low level of courtship activity in the males and an unusually low proclivity toward acceptance by the females. However, I noticed that stray males that had escaped from the mating cages and flown to a large screened window often showed greatly increased aggressive behavior and sexual approaches toward each other. Females placed on the screen near courting males still refused to mate, but when they were restrained by holding the wings together over the back with a pair of flat forceps, the males were often able to copulate. Greater success was achieved by stroking the female's abdomen on the male's antennae to elicit repeated copulation attempts and by moving the female's abdomen to bring her genitalia into contact with the male's. If the female was released at this point, she still attempted to avoid copulation and would often dislodge the male by her struggles. I had better success by pinching the forceps handle with a spring-type clothespin and putting the clothespin across the mouth of a small jam jar. The quiescent male then hung from the female's abdomen until copulation was complete, when he dropped to the bottom of the jar. This method may prove to give better results than either cage or hand-pairing for a number of difficult species.

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A NEW SUBSPECIES OF *ORGYIA LEUCOSTIGMA* (LYMANTRIIDAE) FROM SABLE ISLAND, NOVA SCOTIA

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ABSTRACT. A new subspecies of *Orgyia leucostigma* (J. E. Smith) from Sable Island, Nova Scotia is figured and described.

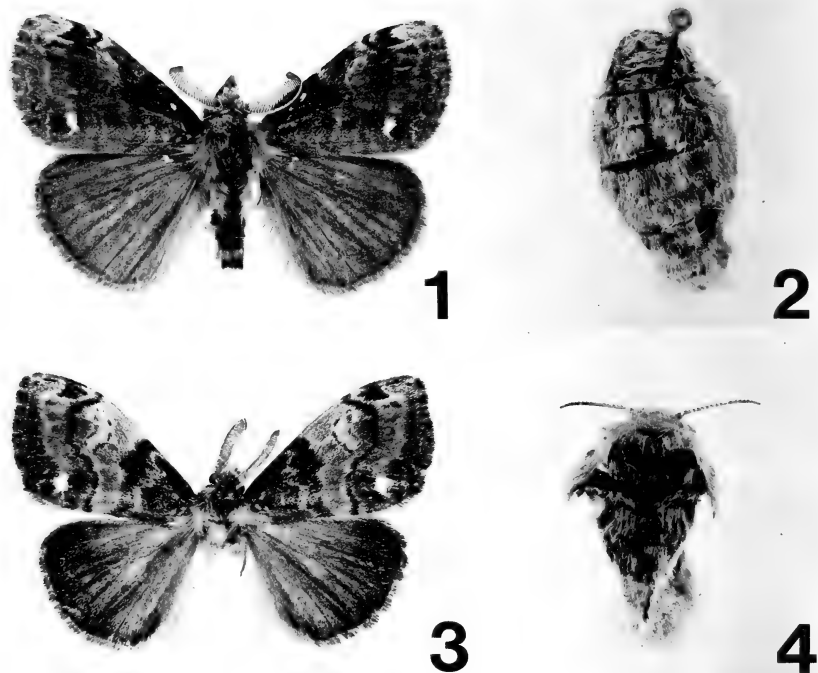
Sable Island is a small, sandy, crescent-shaped island located 150 mi due east of Halifax, Nova Scotia. Until 1975, the Lepidoptera fauna was poorly known with only 23 species (Noctuoidea) listed as occurring on the island (Howden, 1970). Extensive collecting over the last three years by Barry Wright of the Nova Scotia Museum increased this number to 58 (Neil, 1977), adding much to the local knowledge of the Lepidoptera of the island.

One of the more interesting captures taken during the course of this study was a small series of seemingly aberrant male *Orgyia leucostigma* (J. E. Smith) collected in 1976. These specimens had most of the brownish-black ground color of *O. leucostigma plagiata* (Walker) replaced by a dull rusty brown and were very indistinctly marked. Since only a few specimens were available for study, no immediate work was done on them, and a concentrated effort to obtain wild specimens and egg masses for breeding purposes was made in 1977. Numerous specimens subsequently reared under laboratory conditions were similar to the wild specimens collected on the island. It then became evident that this form is genetically different and represents an undescribed subspecies endemic to Sable Island, as mentioned by Ferguson (1978), who also illustrated a male of this subspecies (1978: 85, pl. A, Fig. 13).

Orgyia leucostigma plagiata is known with certainty from only Nova Scotia, Prince Edward Island, and New Brunswick, and represents a Pleistocene relict endemic to the Gulf of St. Lawrence region (Ferguson, 1978). The larvae are extremely general feeders, having been recorded from almost every kind of tree and shrub, and are regarded as a serious pest in Nova Scotia, especially on balsam fir trees.

Orgyia leucostigma sablensis Neil, new subspecies

Description. Male: Upperside of forewing dull rusty brown. Markings and lines as in *plagiata* but generally much more diffuse and indistinct. Median space rusty brown with varying amounts of blackish scales from anterior apex of discal spot to above second anal vein. Light grey of median area found in *plagiata* generally absent, or if present, reduced to a small patch at costa. Basal third of forewing also rusty brown with the darker brown shades of *plagiata* reduced to a small patch at costa. Discal dot



FIGS. 1-4. *Orgyia* spp. 1, *O. leucostigma sablensis* ♂, holotype; 2, *O. leucostigma sablensis* ♀, allotype; 3, *O. leucostigma plagiata* ♂, Lunenburg, Nova Scotia, 21 Aug. 1976, B. Wright; 4, *O. leucostigma plagiata* ♀, McNabs Island, Halifax Co., Nova Scotia, 5 Sept. 1905, J. Perrin.

obscure and indistinct. Antemedial line very diffuse, lighter brown in color than surrounding basal area. Outer third of forewing also rusty brown with a variable amount of blackish scaling present distad of postmedial line. Dark color narrow at apex widening substantially at tornus. Dark brown spot immediately distad of postmedial line reduced or obsolete. Medial and postmedial lines present but diffuse. Fringe concolorous.

Upperside of hindwing solid rusty brown with fringe concolorous or slightly lighter.

Underside of both wings rusty brown, somewhat lighter along the posterior margin of the forewing. A darker brown postmedial line and discal dot present on both fore- and hindwings of some specimens.

Vestiture with coloration as in ground of wings. No visible differences from *plagiata* in antennae, palpi, or vestiture of head and body.

Length of forewing: holotype male, 14 mm; of male paratypes, 10–15.5 mm.

Female. Small wing pads present. Coloration of body pale grey, almost white both dorsally and laterally. Antennae, palpi, and other external structures as in *plagiata*. Vestiture also as in *plagiata*.

Male and female genitalia. Identical to those of *plagiata*.

Types. **Holotype:** ♂, Meteorological Station, Sable Island, Nova Scotia, 11 Sept. 1977, B. Wright (Fig. 1). **Allotype:** ♀, Main Station, Sable Island, Nova Scotia, 26 July 1976, B. Wright (Fig. 2), reared ex larvae on Bayberry (*Myrica pensylvanica* Loisel), emerged 10 Aug. 1977. **Paratypes:** 2 ♂, West Light, Sable Island, Nova Scotia, 3 Aug.

1976, B. Wright; ♂, same data as above, but taken 6 Aug. 1976; 3 ♂, same data as allotype, emerged 10 and 13 Aug. 1976; 17 ♂, 98 ♀, same data as holotype, but collected on 10 Sept. 1977, reared ex ova on artificial medium (Shorey and Hale, 1965), emerged 6–20 Mar. 1978. Holotype and allotype have been deposited in the Canadian National Collection. Paratypes have been deposited in the collections of the U.S. National Museum, Nova Scotia Museum, and the K. Neil collection.

Distribution. The type locality represents the entire known distribution of *sablensis*.

Early stages. Larvae structurally identical to those of *plagiata* found on mainland Nova Scotia, but with a tendency to differ in color. A large proportion of the larvae, as many as 35–40%, resemble those of *Orgyia leucostigma intermedia* Fitch of the eastern United States, in having red heads, a grey dorsolateral band, blackish areas of the body much reduced, and whitish tufts. This type of larva is quite rare on mainland Nova Scotia and comprises only about 1% of the population (Ferguson, *ibid.*).

Foodplants. A general feeder, like other subspecies of *leucostigma*. Larvae collected from blueberry and cranberry (*Vaccinium* sp.), iris (*Iris versicolor* L.), bayberry (*Myrica pensylvanica* Loisel), rose (*Rosa* sp.), and several species of grasses and sedges.

Remarks. *Sablensis* is the first endemic moth to be recorded from Sable Island. This subspecies also represents a Pleistocene relict that survived glaciation on Sable Island and has since evolved into this unique insular subspecies. The flight period corresponds to that of mainland *plagiata* with adults occurring from late July to mid-September.

ACKNOWLEDGMENTS

I thank Barry Wright of the Nova Scotia Museum for his numerous comments and suggestions made during the preparation of this paper and for his review of the final manuscript, and D. C. Ferguson of the Systematic Entomology Laboratory, U.S. Dept. of Agriculture, Washington, D.C. for his review of the final manuscript, and Mary Primrose of Dalhousie University for photographing the types.

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CALLOPHRYS NIPHON (LYCAENIDAE) IN ALBERTA
WITH NOTES ON THE IDENTIFICATION OF
C. NIPHON AND C. ERYPHON

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ABSTRACT. The known range of *Callophrys niphon clarki* is extended 185 miles west into the province of Alberta, Canada with the capture of several specimens in May 1977 and May 1978.

Atypical specimens of *Callophrys eryphon eryphon*, a species closely related to *C. niphon*, possess a mid-cell and an end of discal cell bar thus invalidating an important character heavily relied upon for identifying these butterflies. Some atypical specimens of *C. niphon* have a smeared or rarely absent mid-cell bar. Alberta *C. niphon* show great variation in other characters including those used for identification purposes in keys of major works. Thus, extreme caution is warranted when identifying these two species using existing taxonomic and descriptive literature.

On the basis of identification of two specimens confirmed by Dr. C. D. Bird and three additional specimens (of poorer quality) confirmed by Mr. J. D. Lafontaine, *Callophrys (Incisalia) niphon clarki* (Freeman) is herein reported to occur in jackpine woods in central Alberta (54°5'N, 113°50'W) (Figs. 1 and 2).

Hooper (1973) reports the northwestern range of *C. niphon clarki* to be "the Loon Lake area," Saskatchewan (about 35 miles east of the Alberta-Saskatchewan border at 54°N). Other references to the western range list it simply as southern Manitoba (Brown, 1957; Clench, 1961; Howe, 1975).

The initial collection consists of two specimens in good condition taken along a cutline in a jackpine wood 7½ mi east and 2½ mi south of Clyde, Alberta on 7 May 1977. The immediate topography consists of low rolling hills with a shallow dip to the west. The elevation of the area is approximately 2,100 ft. Vegetation is almost totally jackpine (*Pinus banksiana*) with sparse, low shrub and herbaceous undergrowth. Aspen poplar (*Populus tremuloides*) and shrubs such as saskatoon (*Amelanchier alnifolia*) and rose (*Rosa* sp.) have regenerated along road allowances, cutlines and occasional clearings. *Callophrys augustinus augustinus* (Westwood) and *Callophrys polios obscurus* Ferris and Fisher were also taken at this time.

On 4 June 1977 five additional specimens of *C. niphon*, in poor condition were collected at West Bridges Lake, 2¼ mi north and 6½ mi east of Clyde. This site is approximately 5 mi NNW of the first collection area and in the same type of topography and vegetation

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community. These specimens were all taken on a moist, sandy beach on the west side of the lake. The immediate vegetation was an aspen poplar-shrub wood bordering the lake for about 200 yards before giving way to a jackpine community such as described above. *C. polios* was also taken here.

One additional worn specimen was taken by Mr. T. W. Thormin on 6 June 1977 six mi east of Redwater, Alberta; that is, 22 mi SE of the first collection site.

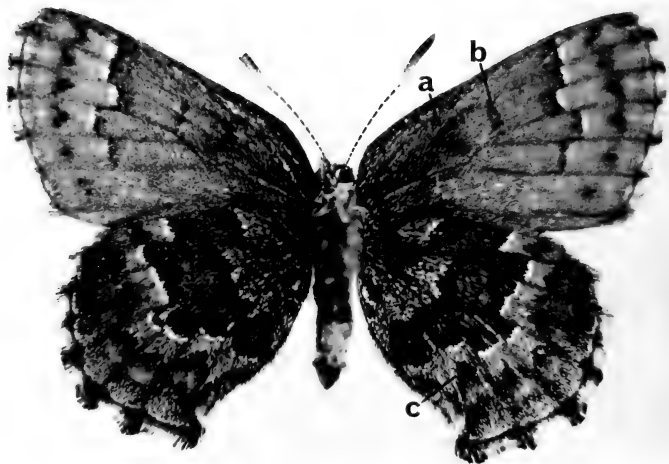
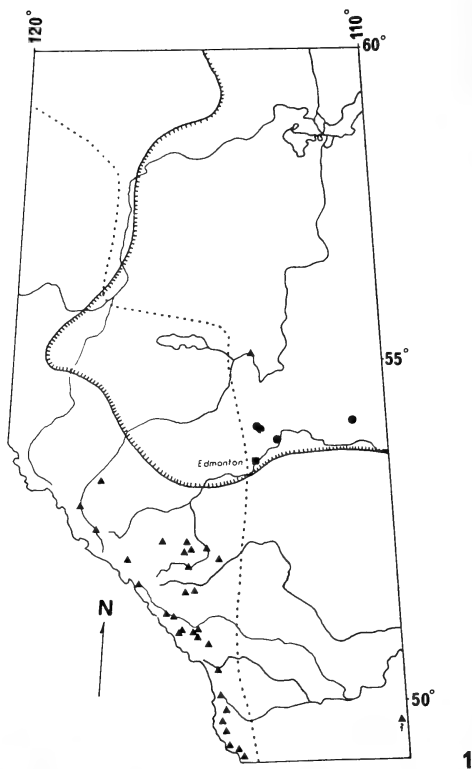
On 6 May 1978 three specimens of *C. niphon* were taken at the first site. On 7 and 13 May 1978 many additional (about 40) specimens were taken in the jackpine wood on the west side of West Bridges Lake. Both sexes were in flight but oviposition was not observed. *C. polios* and *C. augustinus* were flying at both sites as well. T. W. Thormin took several *C. niphon* near Bonnyville, Alberta on 28 May 1978.

Fig. 1 shows the known localities, to date, of *C. niphon clarki* in Alberta. The widespread occurrence of *C. niphon*, both in space and time, suggests this species is well established in the province probably as a breeding population(s). Jackpine, preferred foodplant of *C. niphon*, is found over large areas of central east and northeastern Alberta (Fig. 1); thus additional collecting in these areas may greatly extend our knowledge of the provincial range of this species. The collections herein reported extend the known range of *C. niphon clarki* approximately 185 mi further west than previously determined (Hooper, 1973).

Fig. 1 also shows the Alberta distribution of *Callophrys (Incisalia) eryphon eryphon* (Boisduval), a closely related congener of *C. niphon*. The preferred foodplant of *C. eryphon* (*Pinus contorta*—lodgepole pine) occurs primarily in montane and submontane areas of western Alberta. However, lodgepole pine and jackpine distributions overlap considerably in central Alberta. This raises the possibility of sympatry of these two butterflies in Alberta. With sympatry comes the possibility of confusion in identification and the potential for hybridization. The remainder of this paper will address the first of these possibilities.

IDENTIFICATION OF *C. eryphon* AND *C. niphon*

Identification of the initial *C. niphon* specimens proved to be difficult using the available literature. Examination of six specimens of both *C. niphon* and *C. eryphon* from the Biosystematics Research Institute, the *C. eryphon* collections of both the University of Alberta and University of Calgary, and a consideration of the 1978 Alberta *C. niphon* showed that the characters commonly used for identification



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FIGS. 1, 2. 1, Outline map of Alberta, Canada showing known localities of *Callophrys eryphon eryphon* (triangles) (C. D. Bird, pers. comm.) and *C. niphon clarki* (closed circles). Also shown are the eastern limits of *Pinus contorta latifolia* (dotted line) and western and southern limits of *Pinus banksiana* (toothed line) (both after

are not constant in specimens from different areas. Variation commonly is towards the other species, leading Brown (1957) to question the validity of two species.

Most authors use three characters for identification: presence of both a mid-cell and end of cell dark bar transversely crossing the discal cell on the underside of the forewing in *C. niphon* (a and b in Figs. 2 and 4), while typical *C. eryphon* lack the mid-cell bar (Fig. 3), (Clench, 1961; Hooper, 1973; Howe, 1975). The submarginal dark chevrons on the underside of the hindwing in *C. niphon* are shallowly angled compared to the same on *C. eryphon* (c in Figs. 2 and 3), (Brown, 1957; Clench, 1961; Hooper, 1973; Howe, 1975). *C. niphon* also has more gray scaling on the submarginal line of the underside hindwing than does *C. eryphon* (Brown, 1957; Clench, 1961; Hooper, 1973). These latter two characters show considerable individual variation as well as being dependent upon specimen condition, consequently their usefulness for identification is limited and prone to subjective interpretation.

Presence or absence of the mid-cell discal bar is perhaps the most heavily relied upon distinguishing character used in keys and/or regional works. However, no mention of variability of this character is made.

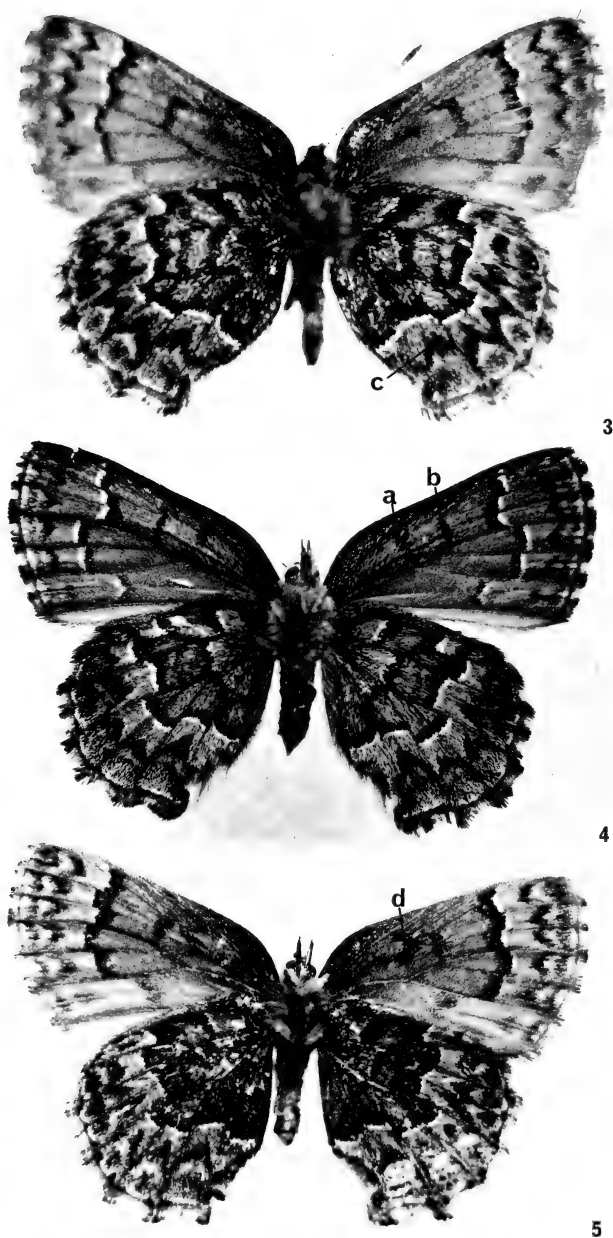
Some specimens of *C. eryphon* possessed a distinct or variously smeared mid-cell bar (d in Fig. 5). Of 41 specimens of *C. eryphon* examined 7 (17%) possessed a mid-cell bar or spot and 5(12%) had that area smeared by dark scaling thus negating determination. Geographic range of these specimens varied from British Columbia to the Northwest Territories but most (36) were from Alberta.

The mid-cell bar, typically present in *C. niphon* was smeared or rarely absent. Fifty specimens were examined (49 Alberta) and 3 (6%) had the bar absent while 9 (18%) had that area smeared or obscured. Extreme variation of other characters including wing checkering; angle of fore- and hindwing chevrons; shape of median bands; hindwing crennation; and most especially color of markings, distribution of gray scaling and ground color was quite evident in the sample of Alberta *C. niphon*. It is unknown whether such variation is typical of the species in other parts of its range. Enumeration and description of this variability of *C. niphon* is intended in a later paper.

In conclusion, when using available literature to key or identify

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Moss, 1949). Question mark indicates an unconfirmed locality for *C. eryphon*. 2, *Callophrys niphon clarki* from Clyde, Alberta taken on 7 May 1978. ×5, a, b, c explained in text.



FIGS. 3-5. 3, *Callophrys eryphon eryphon* from Seebe, Alberta taken on 21 May 1978 (typical form with single discal cell bar). 4, *Callophrys niphon clarki* from English River, Ontario taken on 17 February 1965. 5, *Callophrys eryphon eryphon* from Terrace, British Columbia taken on 3 June 1960 (atypical form with two discal cell bars). $\times 5$, a-d explained in text.

suspected specimens of *C. eryphon* or *C. niphon* care should be exercised. Comparison with long series of each species is desirable; and recognition that character variability could potentially lead to erroneous identifications is necessary.

ACKNOWLEDGMENTS

I thank Dr. C. D. Bird (University of Calgary, Calgary, Alberta) and Mr. J. D. Lafontaine (Biosystematics Research Institute, Ottawa) for confirming the identification of *C. niphon clarki*. Mr. Lafontaine kindly arranged for the loan of specimens from the Biosystematics Institute collection. Mr. T. W. Thormin pointed out the lack of Alberta records for *C. niphon* and allowed me access to his collection. Dr. Bird and Extension Entomology, University of Alberta allowed access to collections in their care. Dr. Bird criticized early versions of the manuscript and provided distribution records for Alberta *C. eryphon*. Dr. D. Barr (Royal Ontario Museum, Toronto) criticized a later version of the manuscript. The manuscript was typed by ROM staff.

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ADDENDUM

Additional specimens of *Callophrys niphon clarki* from Alberta have recently been identified by Dr. C. D. Bird. These specimens represent a northward extension of the known range within the province of approximately 400 miles and a first record for the species from the Northwest Territories. The collection data are as follows:

a) Pine Lake, Wood Buffalo National Park, Alberta: 59°34'N, 112°15'W, 1 June 1974 (1 specimen); 6 June 1976 (1 specimen), Elsie Kuyt, lakeshore, sandy with scattered willow and aspen poplar with white spruce, Banksian pine and mature aspen further back from shore.

b) Fort Smith, Northwest Territories: 60°01'N, 111°52'W, 29 May 1976 (1 specimen), Elsie Kuyt, domestic garden adjoining aspen poplar-whitespruce-Banksian pine, mixed forest.

I am indebted to Elsie Kuyt for allowing me to use her collection data and Dr. Bird for bringing these data to my attention.

LIFE HISTORY OBSERVATIONS ON *HEMARIS GRACILIS* (SPHINGIDAE)

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ABSTRACT. The mature larva of *Hemaris gracilis* is described and figured from material at Groton, Middlesex County, Massachusetts. The foodplant is low bush blueberry, *Vaccinium vacillans* Torrey.

According to recently published material (Hodges, 1971), the immature stages of *Hemaris gracilis* are unknown. There is uncertainty about the identity of its foodplant. This report describes the larval stages and identifies a foodplant for this species.

On 27 May 1978 in Groton, Middlesex Co., Mass., I was looking for *Hemaris gracilis* adults since for several years previously I had taken individuals of this species feeding at the blossoms of early low bush blueberry, *Vaccinium vacillans*. At approximately 1300 I observed a female hovering over the *V. vacillans* but obviously not feeding. As I observed her, she oviposited on the underside of new growth at the extremity of a twig. The egg was retrieved; in the process I lost sight of the adult. With the exception of its very small size the egg was typically sphingiform—pale green and slightly oblong in shape. The color perfectly matched that of the leaf on which it was placed.

I returned to the same area on 30 May and captured a female of *H. gracilis* which I subsequently placed in a "flying" cage. On 1 June 1978 a third female was observed ovipositing on *V. vacillans* at 1630; I was able to retrieve four eggs before the female disappeared. In the meantime I had put cut twigs of *V. vacillans* in the cage with the female taken on 30 May. There were some blossoms on the *vacillans*; in addition lilac blossoms were placed in the cage as a source of food for the moth. Although I never actually saw the caged moth feed or oviposit, she lived for five days. After the moth died I recovered twenty eggs from the cut *V. vacillans*. The location of the eggs on the plant was the same as it had been in the wild but the eggs tended to be laid in small clusters rather than singly as was the case with the free flying females.

A total of twenty-five eggs was collected from three females. The larvae were reared through the fourth instar on *V. vacillans* which was cut with the stems placed in water in the rearing cage. The following calendar was maintained on the first egg retrieved.

27 May egg retrieved

2 June larva hatched—typically sphingiform, pale green in color with a black caudal horn

- 8 June larva entered second instar
12 June larva entered third instar; color patterns become apparent
19 June larva entered fourth instar
25 June larva entered fifth instar
- 1 July larva entered prepupal stage; body color takes on a purple shade
- 2 July larva spins a loose cocoon in debris at the surface of the ground (peat moss in this instance)
- 8 July pupation occurs; the pupa is active but not otherwise distinctive
- 4 August an adult *Hemaris gracilis* ♂ emerges; appears normal in all respects

The larvae from the three *gracilis* females showed no significant variation either among themselves or in color patterns throughout their growth stages. Of the twenty-five larvae, twelve pupae were obtained. Two larvae were preserved in alcohol, two died as a result of accidental injury and the other nine died of unknown causes. The larvae were transferred to high bush blueberry, *Vaccinium corymbosum* L., for the fifth instar as I relocated for the month of July, and *V. vacillans* was not available. Since no mortality occurred during this instar, and the larvae readily accepted the foodplant, it is likely that *V. corymbosum* is a host for *Hemaris gracilis* in areas where it and the moth coexist.

Of the twelve pupae, four moths emerged in late summer—males on 4 and 11 August, females on 6 and 10 August. The remaining pupae are viable and will overwinter. It would appear that in New England there is a partial second brood of *Hemaris gracilis* which flies in August but for the most part the species is single brooded.

Description of the mature larva. Length in resting position 40–48 mm; width of head 6.8 mm; height of head 6.6 mm. Basic color yellow-green. Head slightly darker than body, dull, with extremely fine granulations; a narrow, dark brown line enclosing the anterior four ocelli. Prothorax with a narrow, slightly raised anterior ridge (“cervical shield”) extending down on each side to about twice the height of a spiracle above the level of the dorsal end of each spiracle, light yellowish white, posteriorly tinged with pink, shiny, with a few slight rugosities. Spiracles pink, each with a small white dot in each dorsal and ventral end; sometimes with a small, orange-brown area anterior to it. Entire dorsal area slightly darker green than remainder of body, unmarked, with dorsal aorta showing through slightly darker. On each side a thin, yellowish white line beginning at anterior edge of mesothorax and running uninterruptedly to base of caudal horn. At their anterior ends these lines are slightly closer together than the width of the head; gradually diverging to abdominal segment 2, thence parallel to last abdominal segment, then converging to base of caudal horn. A short, yellowish white line along each edge of tergite of posterior abdominal segment, extending to this segment’s point-

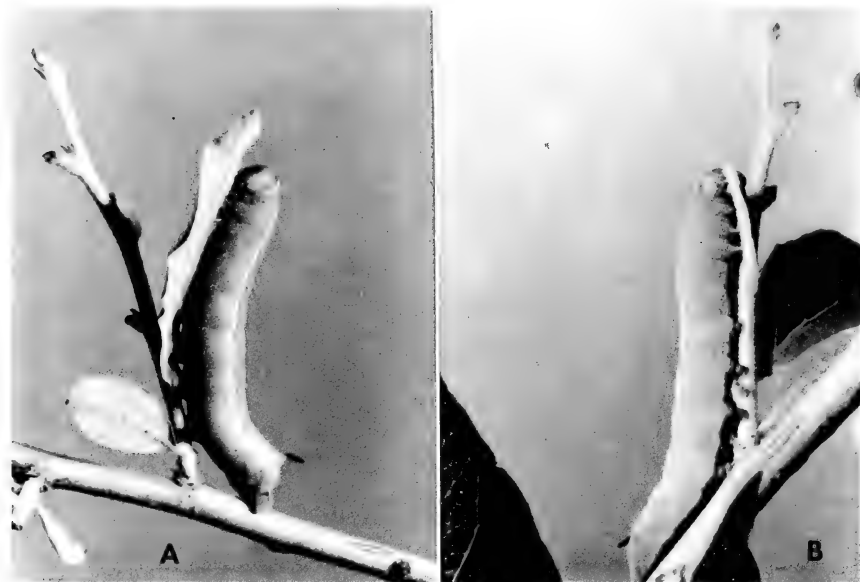


FIG. 1. Mature larva of *Hemaris gracilis*. A, showing dorsolateral yellowish-white line. B, showing dark ventral surface. (Photographs by A. B. Klots.)

ed posterior end. Skin of body smooth, sparsely and very minutely setose with fine, white dots in 7-9 irregular, transverse rows on each segment. Ventral surface of body dark reddish to purplish brown, this broken on mesothorax and metathorax, thence continuous to anal prolegs, extending up on sides to above bases of prolegs, there darker, and with a very slight yellowish upper edge. Legs pinkish brown, darkening to tips. Prolegs of abdominal segments 3-6 very dark purplish brown; last prolegs green, purplish brown ventrally. Horn light reddish brown, darkening toward tip, with sparse setiferous rugosities, its terminal two thirds shinier; slightly shorter than dorsal length of 8th abdominal segment.

Prepupal condition. Entire dorsal area suffused with dull reddish brown, extending laterad to include light dorsolateral lines. Head slightly duller green. Light, raised prothoracic ridge, green lateral areas and dark ventral areas unchanged.

Characterization. From the larvae of *H. thysbe* (Fabricius) and *diffinis* (Boisduval) (see Forbes, 1948, pp. 182-184 and 195-196) the larva is strongly differentiated by its solidly dark ventral surface. Compared with *thysbe* the head and body are smoother, the prothoracic shield narrower and smoother, the horn shorter and the dark, pale-edged dorsal line absent. In these characters it seems to be more like *diffinis*.

Foodplant. *Vaccinium vacillans* Torrey is a preferred foodplant during the larval stage of *Hemaris gracilis*. The strong probability exists that other species of *Vaccinium* also serve as host plants for the moth throughout its range.

Disposition of specimens. The female which was originally caged is pinned and in the author's collection. Four moths emerged from pupae, 2 ♂ and 2 ♀. All, with the exception of one female whose wings failed to expand, are pinned and in the author's collection.

ACKNOWLEDGMENTS

I thank Dr. Alexander B. Klots of Putnam, Connecticut for his invaluable assistance in caring for the larvae during periods of my ab-

sence, describing the mature larva and taking the photographs which accompany this article. I also credit Dr. Hermann Flaschka, Chemistry Department, Georgia Tech, Atlanta, Georgia, for his advice as to how to construct a flying cage in order to obtain eggs from the captured female.

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GENERAL NOTES

NEW *PAPILIO CRESPHONTES* HOSTPLANT

In mid-April 1978 I was examining Torchwood (*Amyris elemifera* L.) shrubs in the understory of second-growth dry hammock on Big Pine Key, Monroe Co., Florida. No rain had fallen for a month, and this particular place was exposed to a relentless parching southeast wind that had wilted all Torchwood at the hammock edge. But inside the hammock, the shrubs looked healthy. Here I was surprised to find ova and larvae in all instars of *Papilio cresphontes cresphontes* Cramer in circumstances theoretically more suitable for *P. aristodemus ponceanus* Schaus. Furthermore, a few *cresphontes* were flying through shaded hammocks here and in known Upper Keys *ponceanus* habitats. Several *cresphontes* females investigated Torchwood but I witnessed no oviposition. The few eggshells found were not necessarily on the youngest growth, and first instar larvae accepted older growth. I gave one of these larvae new leaves from Torchwood growing in full sunlight, and it ate them readily. When I tasted these leaves they had a sharp tang almost like that of mint, followed by a longer-lasting bitter aftertaste. Shade-grown new leaves lacked both these extremes.

I brought six final instar larvae back to New York, hoping to rear them through to adults even though I had no Torchwood growing at home. Surprisingly, they refused mature leaves of *Citrus paradisi* Macf. and etiolated shoots of *Ruta graveolens* L. After wandering in the cage for some days, all pupated. Except for two partly abortive pupae which I preserved, the rest emerged as characteristic but undersized adults.

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ERYNNIS BAPTISIAE (HESPERIIDAE) ON CROWN VETCH (LEGUMINOSAE)

Crown vetch, *Coronilla varia* L., is a European perennial leguminous ground cover introduced to North America after 1890. It has been extensively planted by the Pennsylvania highway authorities to control embankment erosion. This program began in the mid-1930s and accelerated in the past 20 years (Wheeler, 1974, *Can. Entomol.* 106: 897–908). Crown vetch is now thoroughly naturalized in Pennsylvania as a common component of old-field successional vegetation; it has also spread to adjacent southeastern New York and northern Maryland and Delaware. Wheeler (loc. cit.) conducted an insect survey of the plant and found two butterflies breeding on it (counties unspecified): *Colias eurytheme* Bdv. (Pieridae) and *Erynnis baptisiae* (Forbes) (Hesperiidae). He did not consider either to be of potential economic importance.

Shapiro (1966, *Butterflies of the Delaware Valley*, p. 53) judged *E. baptisiae* to be "locally common" in southeastern Pennsylvania but did not find it on *Coronilla*, although *C. eurytheme* was recorded on that plant (p. 38). In 1966 and 1967 it was noted as singletons in the vicinity of *Coronilla* in Montgomery and Chester Counties.

From 10–12 July 1978 I collected intensively in areas of Montgomery, Delaware, and Chester Counties, Pennsylvania which I had often visited from 1955 through 1966. In many of these localities I found *E. baptisiae* the commonest butterfly, a situation never previously observed. Where *Coronilla* was abundant *E. baptisiae* usually outnumbered all other butterflies and skippers combined. Numerous ovipositions on crown vetch were observed, and, notably, male "territoriality"—which is very conspicuous in low-density populations of *E. baptisiae*—was much reduced or even absent. Thirty specimens were collected in an hour at a 0.5 ha stand of the plant in Marple Township, Delaware Co.

This unprecedented abundance may reflect an upward shift in the carrying capacity of the environment for *E. baptisiae* in the presence of a newly adopted, exotic host. A precisely parallel situation is believed to exist with populations of *Pieris napi microstriata* Comstock (Pieridae) on introduced watercress in California (Shapiro, 1975, *J. Res. Lepid.* 14: 158–168). Ongoing monitoring of the range and population levels of *E. baptisiae* where *Coronilla* occurs would be most desirable.

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DOES HESPERIA JUBA (HESPERIIDAE) HIBERNATE AS AN ADULT?

The life history of *Hesperia juba* Scudder is very poorly known. The early stages were described by MacNeill (1964, *Univ. Calif. Publ. Entomol.* 35: 67–77), who observed that "the adults are present from April through October, with some variation according to locality; evidently emergence is rather continuous and there are no distinct seasonal broods." This was inferred from the data on 769 specimens from hundreds of localities, not incorporating long series from single places. For southern California, Emmel and Emmel (1973, *Butterflies of Southern California*, p. 84) record two broods, April–June and August–September. This is closer to the picture which emerges when

long series from single localities in northern California are examined. Since 1972 regular, frequent butterfly sampling has been done in the Donner Pass vicinity (2,100 m), Nevada and Placer Counties, as part of a larger phenological study. During this period 525 individuals of *H. juba* have been examined. Emmel and Emmel (1962, J. Lepid. Soc. 16: 36) collected in Donner Pass from 17 June–26 August 1960 and recorded *H. juba* from 17 June–1 July only. My records, given below, corroborate this spring flight but also indicate an autumn flight missed by the Emmels:

Year	Locality	Spring dates	Fall dates	Spring snowpack
1972	Boreal Ridge	v. 24–vi. 7	viii. 10–x. 4	light
1973	Soda Springs-Norden	not seen	ix. 7–x. 5	heavy
1974	"	vi. 9	viii. 24–ix. 27	heavy
1975	"	vi. 11	ix. 2–ix. 30	moderate
1976	"	v. 14–vii. 1	viii. 20–x. 8	very light
1977	"	vi. 4	ix. 2–ix. 23	light
1978	"	vi. 14–vii. 1	viii. 15–x. 23	very heavy
1979	"	vi. 1–vii. 12	ix. 4–ix. 30	moderate

This is an unusual phenology for a skipper, especially in montane habitats. The fall flight appears just as rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britton, Compositae) comes into flower and ends just as the last individuals of that species go to seed. During this time nightly low temperatures are usually near to below 0°C. Twenty or more *H. juba* may be found on individual rabbitbrush plants, and they are rarely seen elsewhere: feeding occurs throughout the day if the sun is shining and the air warm. Many other insects also visit Rabbitbrush at this time, including tachinid and syrphid flies, a wide variety of bees including *Bombus* spp., several day-flying noctuid moths, and such butterflies as *Vanessa virginiensis* Drury and *Polygonia zephyrus* Edwards (Nymphalidae), *Apodemia mormo* Felder & Felder (Riodinidae), *Neophasia menapia* Felder & Felder (Pieridae), and *Ochlodes sylvanoides* Boisduval (Hesperiidae). All of the autumn *H. juba* are fresh, with bright green ventral hindwings bearing lustrous silvery spots; only at the very end of the flight, in October, do any individuals show noticeable wear or fading, and this is uncommon.

In spring *H. juba* appears shortly after snowmelt, often flying on warm south slopes while the north-facing ones are under 2 m of snow. At this time most flower visits are to dandelion (*Taraxacum officinale* L., Compositae) but many individuals can be seen "body basking" on the bare ground in sunlight, courting, and ovipositing. The population density in spring is consistently about one-tenth of the previous autumn's levels, and contrary to MacNeill's observations there has been little year-to-year variability in numbers. The spring flight is very short, often observed only in one weekly sample. In 1976, a year of record low snowpack, *H. juba* was fairly common on 14 May and singletons were seen weekly to 1 July.

Most strikingly, the average condition of spring individuals is much poorer than in autumn. Although a few could be called "fresh" in appearance, most have the green faded to dull brown and the silver entirely lost. Under a dissecting microscope such specimens show up to 20% scale loss on the ventral hindwing. Dorsally the golden ground color is usually intact but the dark borders appear somewhat faded.

All this points to adult hibernation. Of the five species of butterflies listed above as visiting rabbitbrush, the two nymphalids reappear at the same time as *H. juba* and are generally considered to be hibernators. Like *H. juba* they are very fresh in autumn but appear relatively worn in spring. Also like *H. juba*, they feed almost continuously from rabbitbrush in good weather. The other three species do not hibernate as adults and have only an autumn flight. They all feed only at midday to mid-afternoon. Adult hibernation has never been reported in the family Hesperidae in rigorous climates, but the circumstantial case for it at Donner Pass is duplicated by admittedly less massive documentation in Trinity, Sierra, Plumas, Siskiyou, Shasta, and Alpine Counties.

In the Great Basin at lower elevations *H. juba* also flies at rabbitbrush season and engages in massive, continuous flower visitation.

Could a spring generation emerge in June from eggs laid the past September at Donner? It is difficult to see how. Skippers grow slowly as a rule; in optimal weather development from a June egg to a fall adult requires 8–11 weeks. A September egg would have, on the average, 6 to 8 weeks before continuous snow cover developed. During this time the days are shortening rapidly, and ambient temperatures exceed 10°C for only a few hours a day while nightly minima may reach –10°. An increasing number of days have little or no sunshine. MacNeill found that captive larvae kept outdoors in the San Francisco Bay Area would not feed in cool, cloudy weather but resumed activity immediately in strong sunshine or at indoor temperatures. It is difficult to envision much activity or growth after early October at Donner, and impossible to envision under snow. Moreover, the grasses are in poor condition at this time. The most important spring host seems to be *Agrostis idahoensis* Nash, which is mostly brown in October but grows rapidly after snowmelt. After snow leaves an area adults are generally not seen for 2 or 3 weeks. Ambient temperatures are often high and the days are quite long, but this is a very short developmental time for a skipper! Moreover, most of the *H. juba* at Donner in spring are worn when first encountered. If little or no wear is shown by fall adults three weeks into the flight, why should newly emerged spring animals deteriorate so rapidly?

It is not inconceivable that *H. juba* could have a "mixed strategy" of overwintering as adults, eggs, and perhaps young larvae. The two latter stages are common among Hesperianes. Absolute proof of overwintering will require detection of hibernating adults in midwinter, or the recapture in spring of individuals marked the previous autumn. In the absence of such direct evidence the inferential case is rather compelling.

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Journal of the Lepidopterists' Society
33(4), 1979, 260–261

A MIGRATORY FLIGHT OF *URANIA FULGENS* (WALKER) IN HONDURAS (URANIIDAE)

Urania fulgens has long been known as a migratory diurnal moth. Williams (1930, *The Migration of Butterflies*, Edinburgh; 1958, *Insect Migration*, London) has provided excellent summaries of earlier published observations on their migratory flights. These include records from most of Central America from Mexico to Panama and in Colombia and Ecuador. Although we have seen no prior records of flights in Honduras (they may exist), there was no reason not to expect them there.

Williams (1958, op. cit.) tabulated over sixty records of flights from Central America and found in these some evidence of a change of direction of flight at different seasons (including return flights from Mexico and Costa Rica). He found reports of flights from March to August, with a preponderance to the north in March and April and to the east or southeast in June and September. However, he concluded that more records and more accurate compass-directions are needed. On this basis the following brief note is offered.

On 24 August 1978 while seated on a terrace of the Gran Hotel Tela, Tela, Distrito Atlantida, Honduras, during a light rain near mid-day, we noticed a number of *Urania*

fulgens (Walk.) in flight at an elevation of 10–12 m above ground level. The flight pattern was not random, but directional, and generally southwesterly around two sides of the terrace. The following morning at 0600, upon walking onto the front balcony of the hotel which faced on the main street of Tela, we saw large numbers of individuals flying along the street from northeast to southwest. They flew singly or in small groups at levels ranging from one or two m to 12 or 15 m above the street level. The sky was overcast and a light rain was falling after intermittent heavy tropical showers during the night. Five minute counts yielded more than 150 individuals and we estimate that 1,500–1,800 flew past during the hour in which they were under observation. When we terminated observation at 0700, there had been no visible let-up in the flight.

At about 0800 we left Tela by car for El Progreso. This section of highway runs in a generally northwesterly direction and in the northwesterly stretches, the moths continued to cross the highway toward the southwest in large numbers over a distance of at least 30 km but began to disappear or lose their directional flight as the road moved into the mountains.

Where the road crossed the flight lanes, hundreds of dead or stunned moths were on the highway. Stopping to collect a sample of perfect specimens we found that ants reached them within minutes, eating the abdomens of still-living individuals. However, we obtained 39 freshly-emerged specimens in satisfactory condition in half a dozen brief stops. The sex ratio in our samples was 26 ♂♂:13 ♀♀.

Thus, in the flight observed by us in late August, the direction was from northeast to southwest, in contrast to reports of others for this general time period.

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Journal of the Lepidopterists' Society
33(4), 1979, 261–264

CAPTURES OF LARGE MOTHS BY AN ULTRAVIOLET LIGHT TRAP

Early in April 1978, J. Muller installed a standard black light trap, made by the Ellisco Company, on C. B. Worth's farm in Eldora, Cape May Co., New Jersey (Fig. 1). This trap, plugged into an ordinary electric outlet, uses a tube of only 15 watts, emitting both visible blue and ultraviolet (black) rays. Insects striking the four vertical baffles surrounding the tube fall through a funnel into a collecting chamber containing cyanide or other lethal volatile chemicals. The trap is standard equipment for agents of Rutgers University monitoring the abundance of flying phototropic agricultural pests throughout the state of New Jersey.

Muller had been collecting moths on this farm by other means since August 1972, as part of his statewide survey of the macrolepidoptera of New Jersey (Muller, 1976, *J. New York Entomol. Soc.* 84: 197–200, and unpublished). Since the farm is isolated and not close to competing lights, this new trap presented an opportunity to study the extent to which an ultraviolet light diverts moths from their natural nocturnal functions. It was decided to record all sphingids and larger saturniids that were removed from the environment at this focus (Table 1).

For a few days, from time to time, the trap did not operate well because of exhaustion of the lethal gases. However, the kill (summarized in the table) remains representative for comparative purposes, since the flight period of most species occupies several weeks. In the case of double-brooded species there must obviously be two peaks of abundance; these have not been separated in the table.



FIG. 1. Standard black light trap, the Ellisco Co.

The grand total of moths killed, 330, may look impressive, but compared to the number of smaller forms taken it is insignificant. Each night's catch contained perhaps as many as a half dozen large moths, along with a pint to a quart of smaller ones. The latter fraction must have numbered several hundreds. Thus, over a period of about four months, the trap caught in the neighborhood of 50,000 moths. This may have represented the removal of a considerable number of ovipositing females, and thereby ought to have affected the biomass of foraging caterpillars in the population of 1979.

However, it is difficult to draw conclusions when the status of captured moths is unknown. Have females already laid their eggs? Have males already mated? If both the answers are "Yes," removal of the moths would not affect next year's crop.

Examining the catches of the four commonest species (in those cases when the sexes were largely known), we see that among *luna*, *polyphemus*, *io*, and *imperialis*, 138 males and 13 females were taken (91.4 percent males and 8.6 percent females). These figures suggest first that females may be less mobile and secondly that they may be more strongly motivated to fly on ovipositional errands rather than be diverted by attractive lights.

TABLE 1. Large moths caught in a black light at Eldora, New Jersey, 2 May to 12 September 1978.

Species	Sex			Total	Inclusive dates
	M	F	?		
<i>Actias luna</i> (Linnaeus)	48	4	2	54	2 V to 2 IX
<i>Deidamia inscripta</i> (Harris)	1	1	7	9	2 V to 16 VI
<i>Antheraea polyphemus</i> (Cramer)	12	1	—	13	5 V to 5 VIII
<i>Paonias astylus</i> (Drury)	9	5	23	37	26 V to 24 VIII
<i>Smerinthus jamaicensis</i> (Drury)	—	—	2	2	26 V to 12 VI
<i>Lapara coniferarum</i> (J. E. Smith)	1	2	45	48	26 V to 6 VIII
<i>Hyalophora cecropia</i> (Linnaeus)	3	—	—	3	30 V to 1 VI
<i>Paonias myops</i> (J. E. Smith)	—	—	2	2	30 V to 29 VIII
<i>Darapsa pholus</i> (Cramer)	1	1	16	18	30 V to 12 IX
<i>Cressonia juglandis</i> (J. E. Smith)	1	—	4	5	30 V to 5 VIII
<i>Callosamia promethea</i> (Drury)	—	3	—	3	1 VI to 12 VI
<i>Paonias exaecatus</i> (J. E. Smith)	4	1	17	22	4 VI to 24 VIII
<i>Sphecodina abbottii</i> (Swainson)	—	—	1	1	4 VI
<i>Amphion nessus</i> (Cramer)	—	—	1	1	4 VI
<i>Automeris io</i> (Fabricius)	31	3	1	35	4 VI to 30 VII
<i>Sphinx gordius</i> Cramer	6	—	3	9	12 VI to 30 VI
<i>Ceratomia catalpae</i> (Boisduval)	—	—	3	3	13 VI to 3 IX
<i>Manduca quinquemaculata</i> (Haworth)	1	—	3	4	26 VI to 24 VIII
<i>Eacles imperialis</i> (Drury)	47	5	—	52	30 VI to 12 VIII
<i>Citheronia regalis</i> (Fabricius)	1	1	—	2	7 VII to 26 VII
<i>Hyles lineata</i> (Fabricius)	1	—	1	2	28 VII to 2 VIII
<i>Dolba hyloeus</i> (Drury)	—	—	1	1	5 VIII
<i>Eumorphia pandorus</i> (Hübner)	—	—	1	1	16 VIII
<i>Paratreia plebeja</i> (Fabricius)	—	—	1	1	24 VIII
<i>Manduca sexta</i> (Linnaeus)	—	—	2	2	31 VIII to 9 IX
Total	167	27	136	330	

The obvious question then becomes whether or not males are so drawn to lights that they do not respond to female pheromones. One test of that possibility gave inconclusive results. During the course of these observations, Worth tethered 16 newly emerged *Citheronia regalis* females within a few hundred yards of the light trap. They were definitely in competition with the ultraviolet light source, and cruising wild males had an easy choice of which target they would select. Fourteen females secured wild mates, while the trap took only one male. However, during the same three-week interval, 15 reared and marked males were liberated but none of these was trapped. This species is apparently only mildly phototropic.

A further suggestive finding was that the two trapped female *Eacles imperialis* that were dissected were found to be devoid of eggs.

As an incidental observation, it is interesting that *Callosamia promethea*, a common species in this region, was represented in the trap by three females but no males, the latter being largely diurnal.

This study bears on the question of rather new "light pollution" as it relates to populations of phototropic insects. For several decades it was presumed that new insecticides such as DDT were responsible for the decline of large moths in our great urban centers and their suburbs. However, it has not been clear in more recent years why these insects survived in regions such as Worth's farm in Eldora, New Jersey, where DDT and related insecticides have been used vigorously to combat agricultural pests, mosquitoes and gypsy moths.

The difference may lie in rapidly increasing popularity of mercury vapor lamps for urban street lighting as well as for community and private use. These emit ultraviolet light. Given the number of these light sources, insects must be attracted in inestimable numbers, perhaps withdrawing them from reproductive duties to the point of local species extinction. Of course such lamps do not kill insects, but they immobilize them, rendering them as biologically inactive.

In rural areas the use of this type of illumination is much less common. This may account for the greater abundance of large moths in these areas.

Finally, the light trap contained many other orders of insects, among which Hymenoptera were abundantly represented. None of these was saved for identification, but the possibility remains that some were parasitoids of large moths. In such a case black lights might have a favorable effect on moth populations.

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Journal of the Lepidopterists' Society
33(4), 1979, 264-265

JAMES GRAHAM COOPER (1830-1902)

James Graham Cooper was an important 19th century naturalist in California. Collections of Lepidoptera made by him became the basis for several new species described by H. H. Behr, including *Melitaea quino*. Other entomological material he collected was the basis for new taxa described by J. L. LeConte (Coleoptera) and J. W. Greene (Hymenoptera). New species that were named after him include *Anthocaris cooperii* Behr, *Melitaea cooperi* Behr, both Lepidoptera; and *Lytta cooperi* LeConte, and *Amphicoma cooperi* (Horn), both Coleoptera. A very brief biography by Essig (1931, *A History of Entomology*, Macmillan, New York) is sketchy and inaccurate. More complete biographies by Grinnell (1905, *The Condor*, Vol. 5) and Emerson (1899, *Bull. Cooper Ornithol. Cb.*, Vol. 1) are more complete, but only cite his achievements in ornithology. In researching some of the species of Lepidoptera named by Behr, I have uncovered a fair amount of information on Cooper that may be of benefit to other lepidopterists in the future.

James G. Cooper was born in New York City 19 June 1830. His father was a close friend of James Audubon. He had an early interest in natural history and in 1850 accompanied LeConte on a collecting trip to California. After graduating from the College of Physicians and Surgeons in New York in 1853, he took a position as physician and naturalist on an expedition exploring a potential railroad route through Oregon. In 1861 he was back in California and petitioned J. D. Whitney to join Whitney's California Geological Survey as zoologist. For the next several years he did work with Whitney off and on with the Survey Team. Whitney's chief assistant, W. H. Brewer described him as "a man of more than ordinary intellect and zeal in science, but not a very companionable fellow in camp" (1966, *Up and Down California*, Univ. California Pr., Berkeley). His primary duties with the Survey were to collect plant specimens, but his primary interest was vertebrate animals and not botany as was cited by Essig (op. cit.). During the 1860's he became associated with Behr and the California Academy of Science in San Francisco. His primary interests during this period were fish (both marine and freshwater) and marine animals, and he presented many papers to the Academy describing new species. During this period he collected entomological materials that he supplied to Behr and other specialists. His explorations ended in 1866 when he married Rosa M. Wells of Oakland. He practiced medicine in Oakland, where he lived until 1871. In 1871 he moved his practice to Ventura County and his close

association with the California Academy of Science ended. In 1875 he moved to Hayward and continued to practice medicine there until his death in 1902. He continued his studies in Natural History during this time and The Cooper Ornithological Club, named in his honor, was organized in 1893.

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Journal of the Lepidopterists' Society
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A RECENT RECORD OF *SPEYERIA IDALIA* (NYMPHALIDAE) FROM MANITOBA

On 20 July 1977, Brook Nero (546 Coventry Road, Winnipeg, Manitoba) captured a specimen of *Speyeria idalia* (Drury) in a prairie field, beside Assiniboine Forest, Charleswood, Manitoba. The specimen is a male with a wingspan of 8.7 cm, and it is not too worn. Assiniboine Forest is a 700 acre tract set aside as a natural park by the city of Winnipeg. It is primarily an area of second growth aspen and oak. The collecting site lies within the Park on the west edge, and has been identified as a potential reclamation area to the original prairie. At present, however, it is largely bluegrass with only a dozen or so surviving prairie forbs.

This is the only recent record for *S. idalia* in Manitoba. G. S. Brooks (1942, Canad. Entomol. 74: 31-36) recorded a previous record from "Winnipeg" with the comment that it was a stray that "almost certainly does not breed in the province." It is unlikely, however, that either of these Manitoba records represent strays. More likely they are evidence of small colonies of the species still persisting on tiny remnants of virgin prairie. The larval foodplant of *S. idalia*, the birds-foot violet (*Viola pedatifida*) is an obligate species of mesic prairies, and adult butterflies seldom stray far from areas where it grows.

The two Manitoba records represent the most northerly known records for *S. idalia*. However, the species may have been widespread in occurrence on virgin prairie all across southern Manitoba before these prairies were plowed and converted to wheat fields.

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Journal of the Lepidopterists' Society
33(4), 1979, 265-266

ABERRANT SPECIMEN OF *LYCAEIDES MELISSA MELISSA* (LYCAENIDAE)

The accompanying photo (Fig. 1) shows the ventral view of two fresh specimens I caught while collecting along the road to Deer Creek Campground, west of Heber City (Wasatch Co.), Utah 23 June 1976. The specimen on the right is a normal female *Lycaeides melissa melissa* (W. H. Edwards); the one on the left represents an aberration in which the postbasal spots are lacking and the postmedian spots are almost lacking. The extremely well developed marginal band of crescents indicates that the specimen is referable to *Lycaeides melissa melissa* rather than to *L. melissa annetta* (W. H. Edwards).

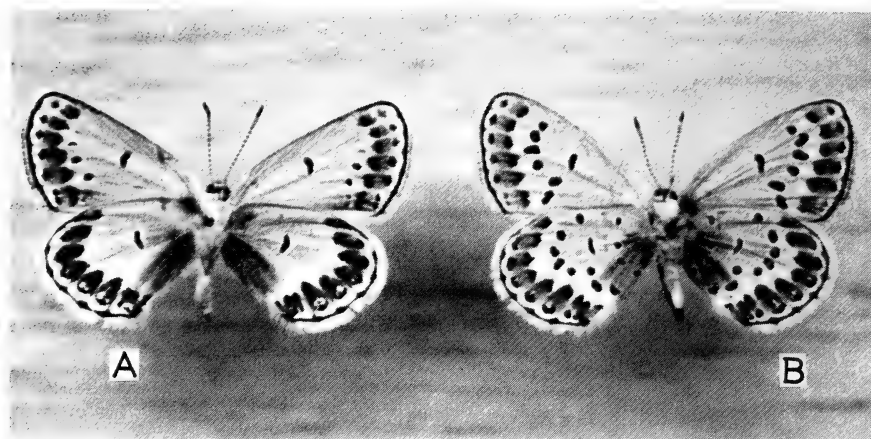


FIG. 1. A, aberrant female *Lycaeides melissa melissa*, ventral surface. B, normal *L. m. melissa* female.

I have shown pictures of this aberration to Dr. Cyril F. dos Passos, Dr. John C. Downey, Harry K. Clench and several other knowledgeable lepidopterists and none can recall seeing a similar specimen, which suggests that such an aberration is rare in the species *melissa*. The aberrant specimen and several normal specimens from the same collecting site have been donated to the Allyn Museum of Entomology, Sarasota, Florida.

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Journal of the Lepidopterists' Society
33(4), 1979, 266-267

POPULATION OUTBREAK OF *CATOCALA PALAEOGAMA* (NOCTUIDAE)

Early in the afternoon of 22 July 1978, I encountered large numbers of the oldwife underwing moth, *Catocala palaegama* Guenée at Illinois Beach State Park in NE Illinois. The park, located on Lake Michigan approximately 1 mi E of Zion, Lake Co., provides an excellent wildlife habitat. Natural features of this extensive tract include prairie, forest, marsh, dunes, stream and several miles of Lake Michigan shore. Low dunes along the beach support an unusual assemblage of plants, including various dune-associated grasses, bearberry (*Arctostaphylos Uva-ursi*) and trailing juniper (*Juniperus sibirica*). Black oak (*Quercus velutina*), sand cherry (*Prunus pumila*), willow (*Salix* sp.), New Jersey tea (*Ceanothus pubescens*), shrubby cinquefoil (*Potentilla fruticosa*), prickly-pear cactus (*Opuntia polyacantha*), wild indigo (*Baptisia tinctoria*), lead plant (*Amorpha fruticosa*) and a proliferation of other plants cover dunes further inland, attracting a variety of unusual moth and butterfly species from early spring until late fall.

The concentration of *Catocala palaegama* was discovered on trunks of black oak at a sandy picnic area close to the lake and adjacent dunes inland. I first observed the moths when I startled individuals at their resting sites, causing them to fly to other trees nearby. From one to as many as five recently emerged specimens were found roosting on nearly every sizeable tree, always on the shady side, from two to five feet

above the ground. When sunlight touched resting sites, individuals moved around the trunk to shade. Observing and collecting was facilitated in these moths as they rested on the same side of all trees at a given time. Forewing markings, showing the considerable variation common in many *Catocala* species, blended well with the grey bark of the oaks.

It would be difficult to estimate the number of underwing moths in this aggregation, or to know how extensive the population was. But certainly many hundreds of specimens were congregated within the park that afternoon. It is likely this phenomenon occurred in this area in other years as well, but this was my first observation of such a remarkable event. While *C. palaeogama* was the predominate species represented, single specimens of *C. lacrymosa* Guenée and *C. amica* Hübner were collected. A large series of *C. palaeogama* was taken, and a number of these, deposited in the collection of Mr. Bryant Mather, Clinton, Mississippi, were subsequently positively identified by Mr. Eric Quinter, American Museum of Natural History. Specimens of the same catch were also deposited in the collections of Dr. Clifford D. Ferris (Laramie, Wyoming), Mr. Patrick J. Conway (Downers Grove, Illinois), Mr. Mogens C. Nielsen (Lansing, Michigan), and the Illinois Natural History Survey (Urbana, Illinois).

It is interesting to note that a collecting trip during the following weekend to the same locality yielded no additional specimens of *C. palaeogama* after the superabundance of the previous week. The area which had been alive with activity at that time was now dead, so far as that species was concerned. However, specimens of other *Catocala* species were collected during the second visit.

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Journal of the Lepidopterists' Society
33(4), 1979, 267-268

NOTES ON THE BIOLOGY OF *BATTUS PHILENOR* (PAPILIONIDAE) IN CENTRE COUNTY, PENNSYLVANIA

Centre County occupies parts of two geographic provinces. The northwestern third lies in the Allegheny Plateau Province, while the southeastern two thirds belongs to the Ridge and Valley Province (Westerfeld, 1959, Pa. Agr. Exp. Sta. Bull. 647: 6-17). The configuration of land surface in the latter is due to the folding of the rocks into parallel mountain chains. These sandstone ridges are oriented from southwest to northeast and average from 550-730 m in elevation. Separated by these ridges are limestone valleys averaging about 310 m above sea level. *Battus philenor* (L.) is largely confined to the stream trenches of these valleys. One such area is along Spring Creek adjacent to the Benner Springs Fish Hatchery about 8.5 km northeast of State College. A small but rather stable population has existed here since at least 1974.

B. philenor is bivoltine with flight periods from 13 May to 16 June and 6 July to 26 August. Fresh adults occasionally observed in September and early October represent a partial third brood. However, these individuals, mostly males, are probably lost to the population since it is doubtful that their progeny would have sufficient time to reach the pupal (overwintering) stage prior to the onset of cold weather.

Males are frequently observed visiting mud puddles, or flying rapidly along the creek and woodland trails and in adjacent meadows. Females are more secretive and are best sought along woodland trails or in open woods. Both sexes prefer pink to purplish flowers such as *Hesperis matronalis* L., *Dipsacus sylvestris* Huds., and various thistles (*Cirsium* spp.). Associated butterflies of special note include *Asterocampa clyton* (Boisduval and LeConte), *Calephelis borealis* (Grote and Robinson), and *Erynnis lucilius* (Scudder and Burgess).

One of the reported foodplants of *B. philenor*, *Asarum canadense* L. (Howe, 1975, *The Butterflies of North America*: 390), is locally abundant on moist, rocky hillsides along Spring Creek. It was assumed that the larvae were utilizing this resource, although none could be located. A similar observation is made by Harris (1972, *Butterflies of Georgia*: 158) for Bibb County where larvae used only cultivated *Aristolochia* even though *Asarum* was present. On 2 June 1978, a female was confined with potted *A. canadense*. She died after 10 days without oviposition. Internal examination revealed that she was mated and had numerous mature ova. We then began a more intensive search for the specific host.

On 4 August at about 1700 h, a female *B. philenor* was observed ovipositing on *Aristolochia serpentaria* L. This is the only *Aristolochia* species in the county and is rare and confined to the Ridge and Valley Province (Westerfeld, 1961, *Castanea* 26: 34). Additional small plants (about 30 cm in height) were subsequently located growing singly or in small groups on the rocky, open-wooded hillsides adjacent to the creek. Numerous ova and first to fourth instar larvae were found on these plants. Most ova were laid on the petioles and/or margins of the upper leaves with up to four individuals per plant. Plants growing in moist, brushy, shaded areas were larger and more luxuriant; however, ova and/or larvae were present in significantly lower numbers. A female captured on 8 August and confined with potted *A. serpentaria* oviposited within hours of confinement. The resulting ova plus 11 field-collected larvae were reared to pupa using potted plants. Enormous quantities of these plants were required to complete larval development and several field trips were needed to collect additional food. On one of these trips several late-instar larvae were observed wandering apparently in search of food. Ehle (1951, *Lepid. News* 5: 103) noted for Lancaster Co., Pennsylvania that the required food (*A. serpentaria*) far exceeded the quantity available at the original site. The last instar larvae consumed the leaves, seed capsules, and stems to within about 5 cm above ground level. Several first instar larvae were transferred to *A. canadense* immediately after emergence and all died without eating. In addition, last instar larvae temporarily confined with this species refused to eat. Saunders (1932, *Butterflies of the Alleghany State Park*: 234) remarked that he was able to get *B. philenor* larvae to eat only *Aristolochia* and not *Asarum* except for one larva which "ate a little Wild Ginger, but did not seem to like it." Of the 25 larvae reared to pupa, 60% diapause and were refrigerated.

Conclusions which may be drawn from these observations are as follows: The use of *Asarum canadense* as a larval food source is to be seriously questioned if not completely discounted. At the Spring Creek site, the amount, distribution, and availability of the host plant, *Aristolochia serpentaria*, appears to be a significant factor in regulating population size. Selection pressure toward producing adult females and larvae with maximum search capabilities would be necessary to maintain a stable population in the absence of immigration. Larval parasitism (or predation) was not investigated, however, all of the field collected larvae (third and fourth instars) were successfully reared to pupae.

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33(4), 1979, 268-269

BOOK REVIEW

BUTTERFLIES OF SOUTH AUSTRALIA, by Robert H. Fisher, 1978. One of the series "Handbooks of the Flora and Fauna of South Australia," issued by the Handbooks Committee for the South Australian Government, 8vo, soft cover, [iii] + 272 pp., 83 text figures, 16 color plates. Price \$9.50 Australian (approximately \$11.00 U.S.).

Beyond the above information, the book gives no clue as to where one might obtain a copy. Word from Entomological Reprint Specialists is that they will stock it eventually but have no copies at this writing.

This little carp aside, the book is a gem. The front matter includes a history of the study of South Australian butterflies, short but informative explanations of classification, life histories (and how to study and record them), anatomy, distribution, how to make and keep a collection. In the back of the book is a systematic list of larval foodplants and the butterflies that use them, a lengthy (6 pp.) bibliography, a lengthy glossary (8 pp.), and an index.

The bulk of the book, of course, comprises the species accounts. The butterfly fauna of Australia numbers in all 366 species of butterflies, of which 64 occur in South Australia. Each of them is figured in color, generally both sexes and both surfaces (with full data appended for each figured individual), and thoroughly discussed: references, terse description, larval foodplants, life history, habits, distribution, abundance, seasons of flight. The color photographs of adults are all variously reduced ($\frac{1}{2}$ to $\frac{3}{4}$), which does not diminish their usefulness except in the smaller species, particularly some of the Hesperidae and Lycaenidae. So much white space surrounds the figures of the latter groups that they easily could have been expanded to life size at no extra cost, and that is unfortunate.

The most outstanding features of this volume, however, are the beautiful black and white illustrations of the living early stages. The photographs are clear and crisp, and unbelievably numerous. As a rough estimate, about 80% of the species are so illustrated, some with supplemental color photographs as well. The figures for each species usually include the egg, larva (often both young and mature), and pupa, in most instances the first published illustrations of them.

The *Butterflies of South Australia* is clearly aimed at the local collector, who is blessed thereby with a guide that lepidopterists in most other parts of the world would envy: authoritative, detailed, packed with information and good illustrations, stimulating in its frequent mention of subjects still in need of careful study. Mr. Fisher knows and presents his subject well, and I recommend his book heartily to butterfly students, not just in South Australia but wherever they may be, if their interests extend even a little beyond the parochial and the philatelic.

HARRY K. CLENCH, *Section of Insects, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, 15213.*

Journal of the Lepidopterists' Society
33(4), 1979, 269-270

BOOK REVIEW

THE BUTTERFLIES OF ORANGE COUNTY, CALIFORNIA, by Larry J. Orsak, 1977. Center for Pathobiology, Museum of Systematic Biology, University of California, Irvine. 349 pp., 7 halftone plates, 56 text figs., 4 maps. Paperback. Price: \$4.00.

This book is more than a regional checklist; it is a treatise on butterflies designed to be independently useful to the beginning collector. The species accounts which form its main body and purpose are preceded by extensive introductory material on classification, variation, structure and behavior; much of it common to most butterfly manuals, but other aspects (e.g., sound production, hilltopping, nectaring) seldom treated outside the periodical literature and consequently less easily available. Several appendices contain additional general information.

In content, therefore, the work is exhaustive and informative. Its organization, however, is another matter. In this respect it suffers certain shortcomings which make its use difficult, especially for one not already familiar with the fauna it covers.

The author evidently enjoyed the luxury of unlimited space. He quotes full label data from Orange County material in several private and institutional collections. Large blocks of these data from the same localities differ only in terms of collection dates and number and sexes of specimens, with the localities repeated in line after line. Surely this could have been condensed with no loss of information.

Text figures, many of them very useful ones of larval foodplants, are often inserted into species accounts with their explanations in the same type face as the rest of the text, so that its smooth flow is interrupted and one must search for the continuation of the main text. This confusing feature could have been eliminated by the use of a smaller type for the figure legends.

But by far the biggest problem is that the genera within each family are arranged alphabetically instead of in scientific order, not only in the main text but in the appended checklist as well. I am entirely unable to comprehend the rationale for this procedure. Thus, in the Lycaenidae one finds blues and hairstreaks jumbled together with the coppers in their midst, while among the nymphalids such closely related genera as *Cynthia* and *Vanessa* are separated by no fewer than seven others of more distant affinities. The result is a feeling of complete disorientation, making an overall impression of the area's butterfly fauna at a glance very difficult to obtain.

Despite these reservations, all but the last comparatively minor, the book is a mine of information if one is willing to do a little digging, modestly priced and a worthy addition to the literature of the still-rich butterfly fauna of southern California. The author's expressed primary purpose of recording distributions "before habitats are destroyed and the memories of veteran Orange County collectors fade" is very commendable and has been well realized.

RODERICK R. IRWIN, *Illinois Natural History Survey, Urbana, Illinois 61801.*

EDITORS' NOTE

The editors wish to extend their sincere appreciation to all persons who have given generously of both their time and knowledge while serving as reviewers for manuscripts submitted to the *Journal* during the past two years. The following persons have reviewed one or more manuscripts during the preparation of Vols. 32 (1978) and 33 (1979):

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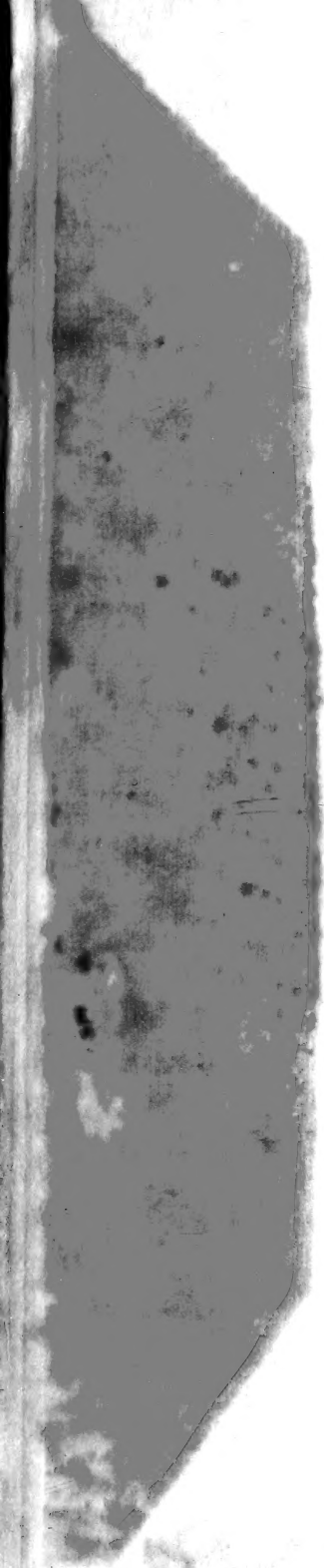
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